COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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June 1951

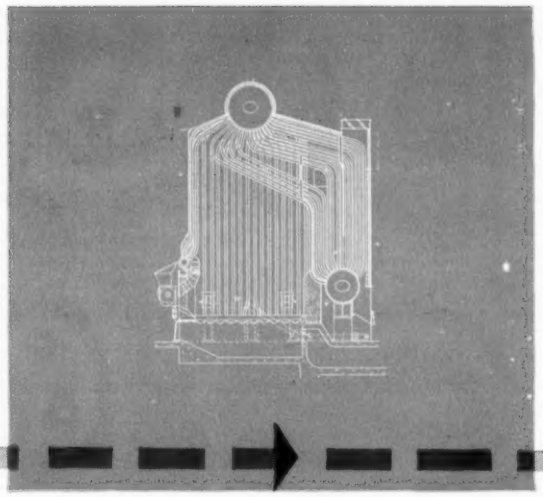
Lee Steam Station of Duke Power Co.: see p. 36

Lee Steam Station Now in Service ▸

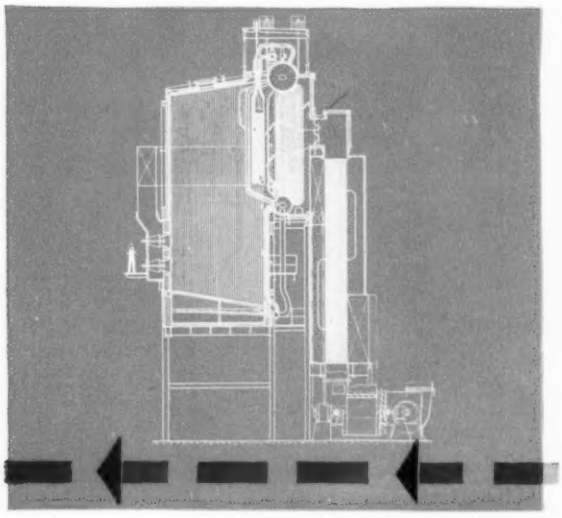
Gamma-Ray Tests of Pipe Welds ▸

Design of Large Modern Stacks ▸

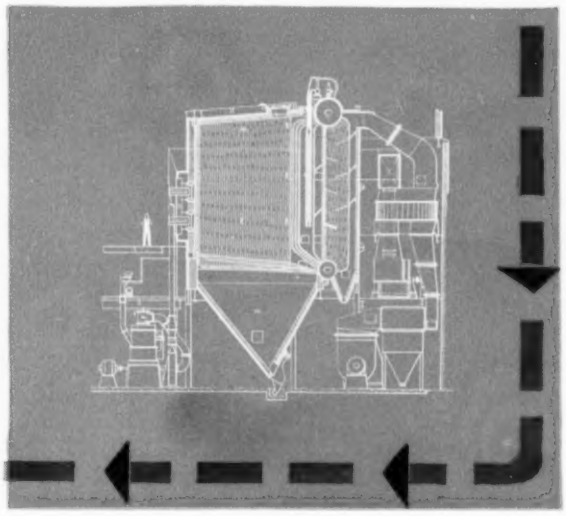
ONE VU LEADS TO ANOTHER



VU-10 Unit fired with C-E Spreader Stoker (dumping grate type). VU-10 Boilers range in capacity from 10,000 to 60,000 lb of steam per hr. May also be fired by underfeed or traveling grate stokers, or by oil or gas.



VU-50 Unit fired with natural gas or oil. Design provides for future pulverized coal firing. Capacity of unit shown is 350,000 lb of steam per hr; operating press.—920 psi; steam temp.—905F.



VU-50 Unit fired with pulverized coal using C-E Raymond Bowl Mills. The capacity of unit shown is 150,000 lb of steam per hr; operating pressure—600 psi; steam temperature—700F.

When VU Boilers were first put on the market, *all* of them, quite naturally, had to be *sold*. Now a very substantial percentage are *bought*. Bought by companies that know by their own first-hand experience what they can expect in day-in and day-out performance—for example:

A paper company some years ago, in urgent need of more capacity, purchased a VU Unit. It went on the line, and—under wartime demand—*stayed there* for 432 days without a shutdown. What do you think they bought when next in the market in 1946? That's right . . . another VU (much bigger than the first).

An automobile company installed its first VU Units (2) in 1947. Two more were ordered for another of its plants in 1948; then three more units for a third plant in 1949 and two more for still another plant in 1950.

A refinery ordered its first VU Unit in 1937. In 1941 another was installed and still another in 1950. For another of its plants two units were ordered in 1942 and a third in 1947.

An electric utility company installed its first VU Unit in 1941. Two more units were ordered for another of its plants in 1947, a unit for a third plant in 1946 and still another for a fourth station in 1949.

* * *

And so it goes—in all sections of the country—and abroad—industry after industry ordering and *reordering* VU Boilers. There must be a reason—and there is. The VU's advanced design, rugged construction and consistent reliability have become a service-proved answer to lower steam costs. You can choose VU with confidence based on the experience of companies in *your* industry, in *your* area.

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COMBUSTION

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June, 1951

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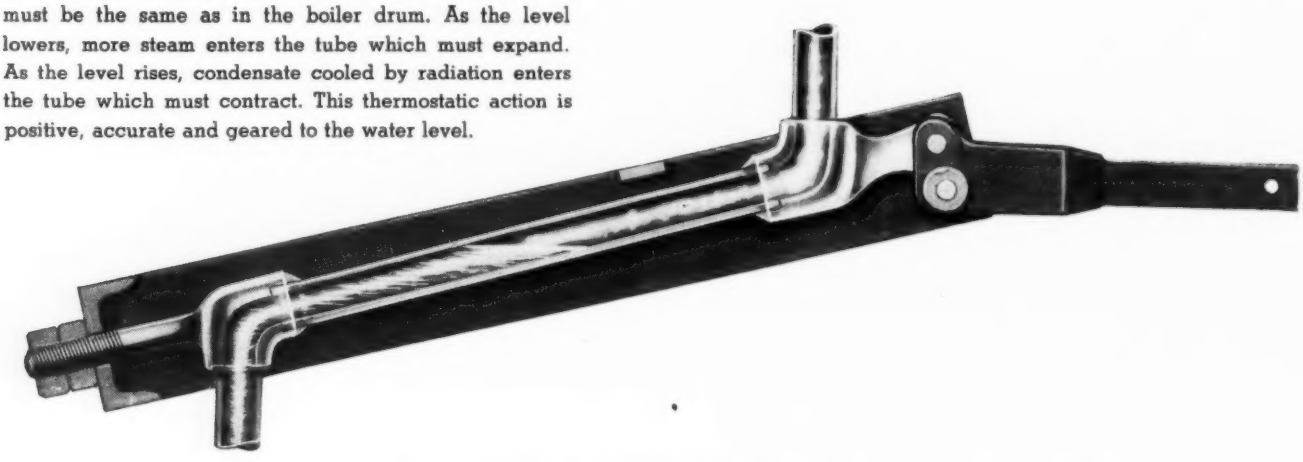

What more positive force could you want to move a valve than that created by expansion and contraction of metal subjected to temperature changes? That was the reason COPES in 1898 first used a thermostatic tube to actuate a feed water regulator valve.

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BOILER FEED WATER REGULATION

Editorials

Organization of Research

Can there be too much organization of research? A look back to the nineteenth century and the freedom of the independent investigator may lead to the desire to return to the time when it was possible to engage in research because of the sheer enjoyment of special interests. But today it is not as feasible to shift from one specialty to another because of the vast amount of knowledge on record and the complexity of new subjects now being explored.

At the dedication some weeks ago of an addition to the Du Pont Company's Experimental Station in Wilmington, Delaware, Dr. James B. Conant, president of Harvard University, contrasted the amateur scientist, as represented by men like Priestley and Lavoisier, with the professional scientist, the applied science laboratory and the engineering group of today. He raised the question as to how organized research could carry on in the future unless means were found to encourage the "uncommitted investigator." This is a serious problem involving consideration of the relationship of freedom and planning. The type of research man that Dr. Conant mentions would need considerable freedom, and his success would largely be dependent upon the "unexpected corners" he could turn without encountering limitations imposed by planning.

The number of uncommitted investigators that might be permitted to seek new frontiers of science and technology is relatively small, but the potential benefits from their efforts are large. Once the unexpected corner is turned, organized research can make a concerted attack upon the new problems uncovered and obtain the desired solutions. In this manner some of the benefits of the lone-wolf type of inventor of bygone days will accrue to today's highly organized research.

Re-employment of Oldsters

More and more firms in the engineering field have been establishing the policy of compulsory retirement at sixty-five, as a result of which there are available increasing numbers of experienced and able engineers in that category. This happens at a time when military and civilian requirements are making heavy demands on the younger technical personnel in industry, with the added fact that recruitment of young engineering graduates from colleges faces a decreasing figure for several years to come.

In view of this situation, there is a feeling in some quarters that it may be uneconomic to discard the ripened experience of many of the older men, even though it may be expedient to assign them to somewhat less arduous tasks. Moreover, a physically able retired engineer, unless self-employed or willing to engage in some non-technical work, finds it most difficult to make new connections in his specialized field.

One solution on a limited scale has just been announced by General Electric Company which has assigned some twenty retired engineers, with an average of forty-one years of specialized experience to their credit, to man the "More Power to America" exhibition train which is touring the country. These men replace an equal number of young men who are released for defense work or laboratory duties. Furthermore, it was pointed out that some of these retired engineers had been intimately associated with the development of much of the equipment exhibited on the train and thereby are exceptionally well qualified to demonstrate and advise as to its use. Had it not been for this solution the tour of the train would, most likely, have been suspended indefinitely.

This example can be emulated in many ways under varying circumstances and undoubtedly many firms are giving serious thought to the idea.

Availability

As units become larger the matter of availability assumes increased importance, inasmuch as forced outage, or excessive outage for maintenance, means both idle fixed charges and dollar loss in greater fuel consumption through the necessity of shifting load to less efficient plants on the system. This may run into vast figures for present-day large units. In fact, for one important station it has been calculated that a difference of 1 per cent in the availability of a single unit is worth around four thousand dollars an hour.

Fortunately, experience and design data accumulated over the past few years, together with certain metallurgical advances and a better understanding of conditions promoting outage, have made for more rational design and, in general, contributed to higher availabilities. This has justified the widespread adoption of the unit boiler-turbine arrangement.

From time to time, in isolated cases, performance data have been released as to availabilities attained, but it has been some years since the Prime Movers Committee published the results of a comprehensive survey on this subject. Might it not be both informative and helpful if up-to-date information of this kind were available?

Exterior view of Duke's Lee Station; cooling tower on right

Lee Steam Station Now In Service

THE Lee Steam Station, the third postwar power plant constructed by the Duke Power Company, contains the first postwar reheat units to go into service in the Southeast. It is part of a construction program which, over the period of 1948–1953, will add 980,000 kw of continuous capability to the steam-electric stations of the Duke system. The Lee Steam Station is located on the Saluda River in Anderson County, S. C., in the southwest portion of the principal industrial area of the two Carolinas. The location is 14 miles east of Anderson and about 17 miles southwest of Greenville.

The initial installation at Lee Steam Station consists of two reheat turbine-generators, each having a nameplate rating of 90,000 kw and a continuous capability of 100,000 kw. Throttle steam conditions are 1250 psig, 950/950 F. Provision has been made for the future installation of a third unit.

Engineering planning for the station was started in 1948 and the first construction took place in May 1949. Unit No.1 was placed in commercial service on March 11, 1951, and Unit No. 2 is expected to follow in July of this year.

Two reheat units, each of 100,000-kw continuous capability, make up the first section of this new station. An unusual feature for a plant of this size is the use of a cooling tower to augment the supply of condenser cooling water during the times of low river flow. Experience at time of starting the station indicates no unusual operating problems attributable to reheat cycle.

Duke Power Company operates in the Piedmont section of North and South Carolina. The territory embraces a belt about 100 miles wide and 260 miles long from Virginia on the northeast to Georgia on the southwest. Total energy production in 1950 was 7,290,000,000 kwhr, which represents an increase of 23.4 per cent over 1949 and 82 per cent over 1945. The textile industry, which is decentralized throughout the Piedmont section, accounted for about 53 per cent of the power sales in 1950.

The history of the Duke Power Company dates back to 1904 when J. B. Duke became interested in a small hydroelectric development on the Catawba River near Rock Hill, S. C. The engineer responsible for this first station was W. S. Lee, for many years vice president and chief engineer of the Company and the man for whom Lee Steam Station is named. Messrs. Duke and Lee believed in conservation of water resources

and were pioneers in unified river-basin development and operation, including construction of storage reservoirs and auxiliary steam plants.

The first steam "stand-by" plants on the Duke system, built in 1911, were rated at 6,400 kw and had a coal rate of three pounds per kwhr. The first large, pulverized-fuel-fired plant, of 70,000-kw capacity was built in 1926, following the 1925 record drought. However, the system remained predominantly hydro until 1940 when the steam plant production exceeded 50 per cent of the total. The postwar construction program of the Company is changing this picture materially so that in 1951 the steam-electric plants, which will constitute 68 per cent of the system capability, will account for about 82 per cent of the total kilowatt-hour output, assuming a median water year.

Upon completion of the Lee Steam Station, the estimated capability of the system, on the basis of median stream flow, will be 1,525,000 kw, made up of the following:

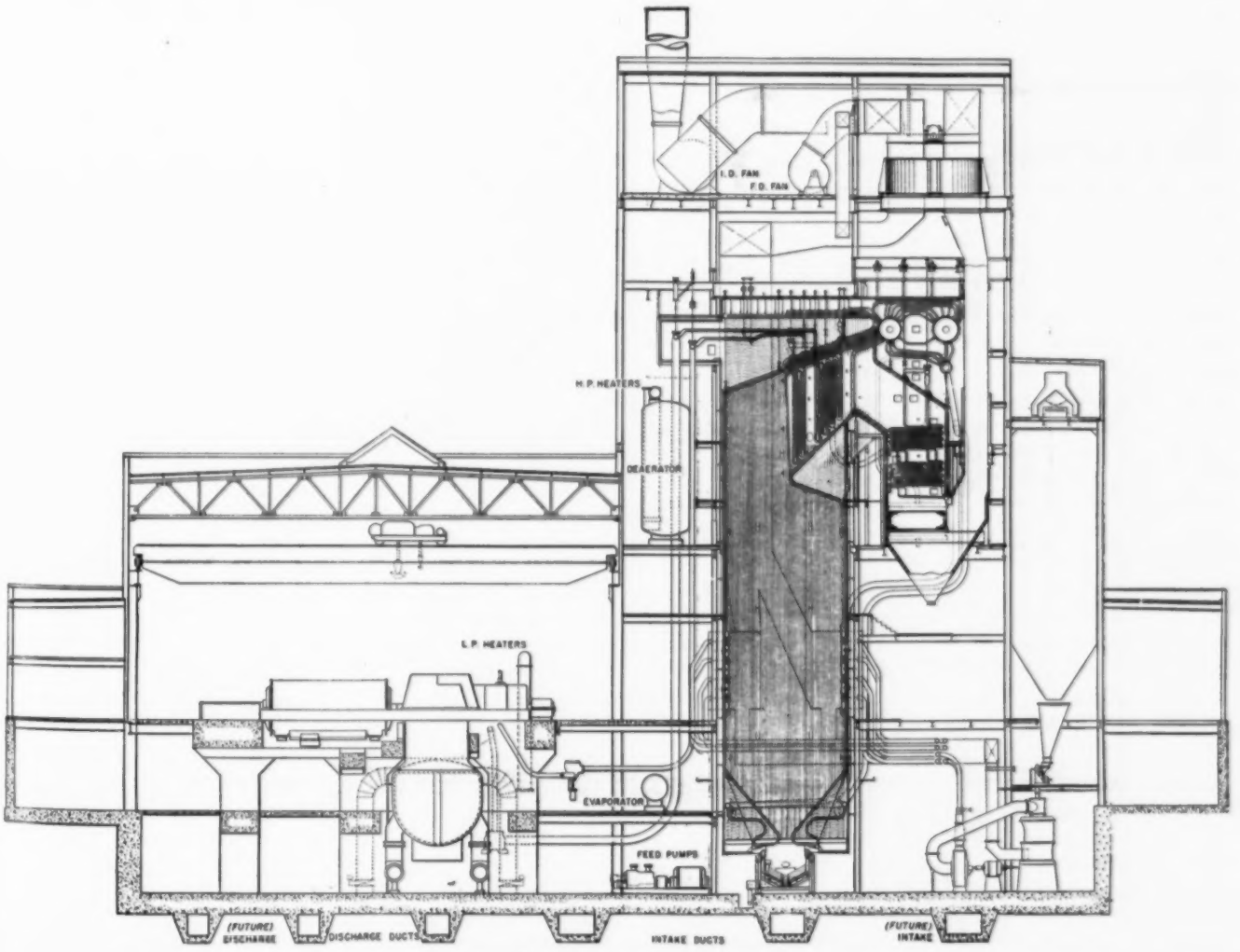
Hydroelectric plants	430,000 kw
Steam-electric plants	1,037,000 kw
Purchase contracts	58,000 kw

When the construction program now under way is completed in 1953, the total estimated capability will be over 2,000,000 kw.

Selection of the Site

The location of Lee Steam Station was chosen to fulfill a need for additional generating capacity in the southwestern portion of the system. Several sites were studied and investigated, with the one finally selected most adequately meeting the requirement of close proximity to the region's load centers. As will be elaborated upon later, the Saluda River does not have sufficient flow to meet condensing-water requirements at all times. This necessitated the installation of cooling towers. However, studies made of alternate sites not requiring towers indicated that the reduction in transmission-line costs and losses more than offset the penalty of the cooling-tower requirement.

An economic comparison was made of four steam cycles for a turbine-generator having a name-plate rating of 90,000 kw and a continuous capability of 100,000 kw. Proposed throttle conditions were 1250 psig, 950 F; 1450 psig, 1000 F; 1250 psig, 950/950 F; and 1450 psig, 1000/1000 F. Apart from its improved water rate and higher thermal efficiency, the reheat cycle was made even more attractive because of the 11 per cent smaller condenser-cooling water requirement at a site where stream



Sectional elevation through station

flow was limited during certain periods of the year. The final choice for throttle conditions was the 1250 psig, 950/950 F reheat cycle, which was selected on the basis of providing the greatest return on the additional investment over the 1250 psig, 950 F non-reheat cycle.

Cooling Tower Study

A study of the available records of stream flow in the Saluda River during the 20-year period of 1930–1949 showed an average flow of 750 cfs, and a minimum weekly flow of 139 cfs. However, the record low flow in this territory occurred in 1925 and is estimated at 100 cfs, at the site. The stream-flow requirement for condensing and station service for the two units at 100,000-kw load, with two circulating pumps per unit, is 340 cfs. Over the 20-year period of the study the stream flow reached or exceeded 340 cfs during 84.5 per cent of the total time. In 1941, the year of minimum flow during the 20-year period, 340 cfs was available 54 per cent of the total time. For operation with only one circulating pump per condenser, the station requirement is 240 cfs, which would have been available 95 per cent of the time in an average year and 74 per cent of the time during the year 1941.

An economic study was made to determine how much cooling-tower capacity could be justified for operation during periods when stream flow was insufficient. This study included capital costs, charges for power to operate the cooling-tower system, losses in station efficiency during an average year and loss in station capacity during a period of minimum stream flow. It was found that only a minimum of cooling-tower capacity could be justified and the choice was a cooling tower rated at 50,000 gpm (110 cfs) at 75 F wet-bulb temperature with 16 deg F approach and 23 deg F range.

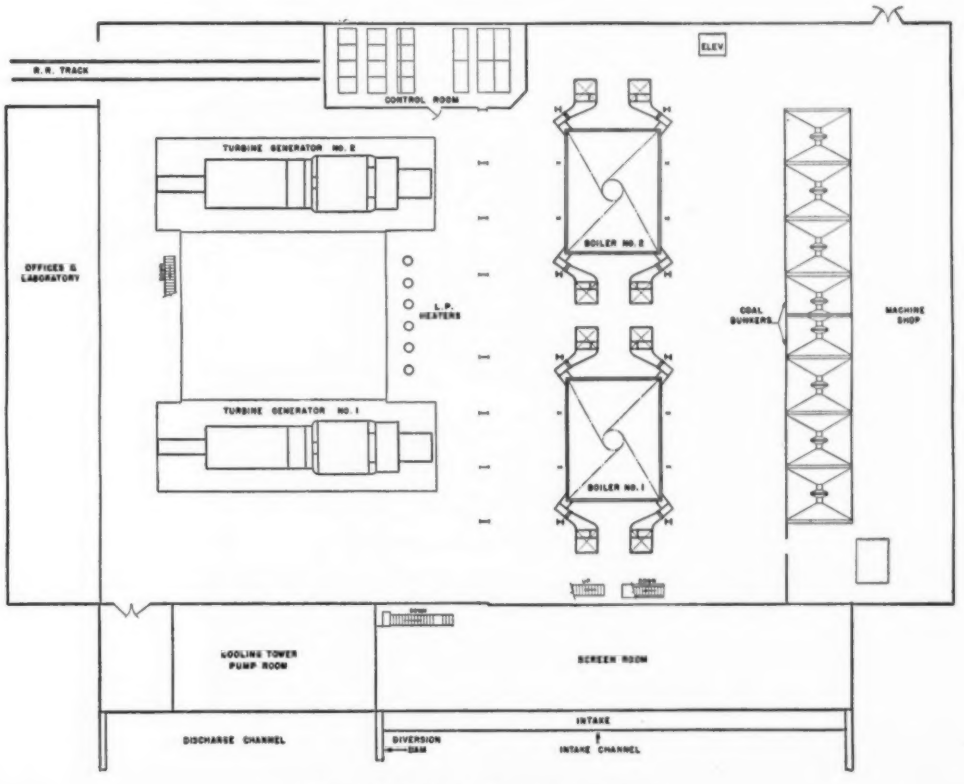
Steam Generating Units

The two steam generating units, built by Combustion Engineering-Superheater, Inc., are of the radiant-reheat, single-pass type and have water-cooled furnaces, Elesco two-stage superheaters, interstage reheaters and finned-tube economizers, and Ljungstrom air preheaters. They are fired by tilting tangential burners under automatic control and supplied by C-E Raymond bowl mills. Design pressure is 1450 psig, with superheater outlet conditions of 1295-psig, 950-F primary steam and 405-psig, 950-F reheat steam. Each unit has a rated capacity of 750,000 lb per hr of primary steam and 645,000 lb per hr of reheat steam. At this rating the furnace heat release is 15,600 Btu per cu ft and 94,000 Btu per sq ft of effective projected surface. The gas temperature entering the superheater is 2,040 F (corrected to MHVT basis).

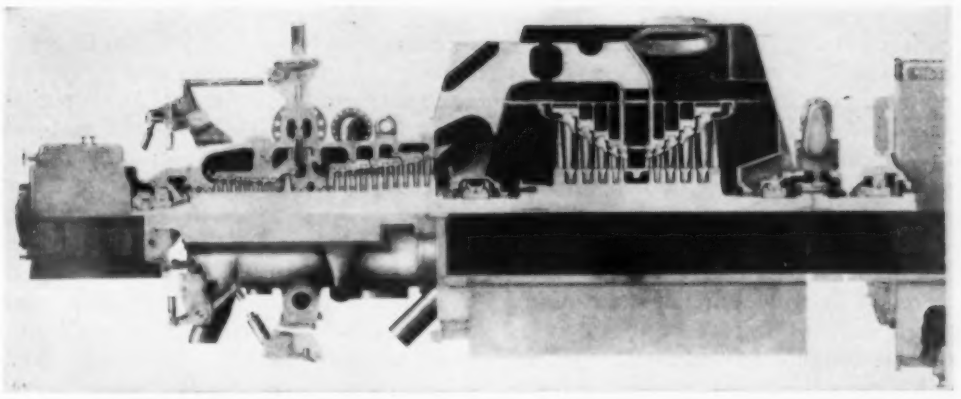
Bituminous coal for the station is obtained from the Virginia, Tennessee and Kentucky coal fields. The steam generating units are designed to burn a wide variety of coals with a minimum of trouble due to slag and fly ash.

The units are suitable for burning natural gas when and if it becomes available. The tilting tangential burners of the steam generating units are readily adaptable to conversion for this form of firing.

Each of the boilers is supplied by four C-E Raymond bowl mills with exhausters. Each mill has a nominal capacity of 32,000 lb per hr when pulverizing 55 Hardgrove grindability coal, with a maximum of 10 per cent moisture, to a fineness of 70 per cent through a 200-mesh screen. Each mill supplies one burner in each of the four corners of the furnace, there being a total of 16 burners.



Plan of station at operating level



Semi-section of typical tandem-compound reheat turbine

Courtesy of General Electric Co

Initial steam temperature is controlled by means of tilting burners supplemented by desuperheating. Reheat temperature is controlled primarily by tilting burners. A two-element steam-temperature control is provided using air flow as the second element and as an anticipatory factor.

The two-stage superheaters each contain 32,460 sq ft of $2^1/_8$-in. O. D. tubing. Provision is made to blow out the superheaters and reheaters in the event of a prolonged shutdown.

Each economizer contains 15,600 sq ft of 2-in. O. D. tubes. Two Ljungstrom air preheaters are installed per boiler, each having a heating surface of 90,800 sq ft with 62-in. elements.

There are two forced-draft fans, two induced-draft fans and two stacks per steam generating unit. This dual arrangement was selected primarily to improve operating availability of the individual boilers since there are no interconnections between the two boiler units. With one set of fans in operation sufficient steam can be generated in the boiler for a 60,000-kw load on its turbo-generator. The unlined steel stacks are essentially extensions of the induced-draft fan discharge nozzles. It was found less expensive to provide the individual stacks than to build a larger single stack with breechings and dampers.

The forced-draft fans are of the Westinghouse-Sturtevant Turbovane type. Each fan is designed to deliver 33,000 cfm at a static pressure of 12.9 in. and is driven by a 300-hp motor. Volume control is effected by means of movable inlet vanes which are positioned by the combustion control system.

The induced-draft fans, each of which has a capacity of 215,000 cfm of 302-F gas against a static pressure of 10.7 in., are also of Westinghouse-Sturtevant design and each fan is driven by a 500-hp motor through an Electric Machinery Mfg. Co. magnetic coupling with Regutron control.

Turbine-Generators

There are two General Electric turbines which are rated 90,000 kw at 3600 rpm. The designed capacity of each turbine is 100,000 kw at 3-in. Hg absolute back pressure. The turbines are tandem-compound, double-flow units with seven stages between the initial steam admission and the admission of the resuperheated steam at intermediate pressure. There are ten stages in the intermediate section and five stages in the double-flow low-pressure section. Steam is admitted at 1250 psig, 950 F, is resuperheated after the first seven stages to 950 F and exhausts to the condenser.

The three-phase Y-connected 13,800-volt, 60-cycle generator is hydrogen-cooled. At 0.5-psig hydrogen pressure it is rated 90,000 kw, 112,500 kva at 0.8 pf and 0.9 short circuit ratio. At 15-psig hydrogen pressure its capacity is 103,500 kw, 129,375 kva at 0.8 pf. This generator has the highest rating at 0.5-psig hydrogen pressure of any 3600-rpm generator now in service. Each generator is provided with geared main and pilot exciters with voltage-regulating equipment for high speed excitation.

These turbines are outstanding examples of the new design of G-E reheat turbines. The accompanying turbine cross-section illustrates the general arrangement and construction of this type reheat unit. In this illustration there are eight stages ahead of the resuperheater because of the higher initial pressure as compared with the 90,000-kw turbines at the Lee Station.

The reversed-flow high-pressure section is the distinguishing feature of this design. It concentrates the high steam temperature in a relatively small portion of the casings and eliminates any significant temperature gradients across the inner-shell walls by placing the main-steam inlet passages adjacent to the reheat inlets. This design feature also reduces the load on the thrust bearing. Including the high-pressure and reheat stages on a single shaft span contributes to minimum overall space requirements and maximum simplicity. As a matter of fact, these reheat units are only a few inches longer than a corresponding non-reheat unit.

Water sprays in the crossover have been provided for flexibility of operation at zero or near zero load.

While the 90,000-kw machine in the Lee Steam Station is the first of the series of machines to operate at the particular turbine and generator rating mentioned, the results obtained on this unit have confirmed the confidence of the Duke Power Company engineers in the reheat cycle.

Condensers and Cooling Towers

Each turbine exhausts to a C. H. Wheeler Mfg. Co. 65,000-sq ft, two-pass condenser containing 9550 Admiralty-metal tubes, No. 18 BWG, 26 ft 3 in. long, and requiring cooling water at the rate of 67,000 gpm. The condensers are of the dual-bank, divided-water-box design.

In starting up, condenser air evacuation is performed by a Nash rotary vacuum pump which is designed to

produce a 21-in. Hg vacuum. When the steam pressure reaches 300 psig, Wheeler steam-jet air ejectors take over and are used for regular operation of the condensers.

Two circulating water pumps and duplicate condensate pumps, all of the horizontal centrifugal type, serve each condenser. The condensate pumps are of the re-entry type, rated at 1150 gpm at 490-ft head and are driven by 250-hp motors. The circulating pumps are rated at 33,500 gpm against a head of 26.1 ft and are driven by 300-hp motors.

For the first two units of the station a Foster-Wheeler 10-cell induced-draft cooling tower is installed. The tower is designed to cool 50,000 gpm from 114 F to 91 F with an air-inlet wet-bulb temperature of 75 F. The cooling-tower pumps take their suction from a chamber at the end of the circulating-water discharge ducts. An overflow weir, on the river side of the chamber, returns to the river all water in excess of that pumped to the cooling towers. From the tower the water flows by gravity back to the circulating-water intake bays where it passes through the traveling screens on its path to the condensers.

To prevent recirculation of condensing water and to insure an adequate pool, a 10-ft high concrete diversion dam, equipped with sluice gates, was built across the Saluda River with bulkhead section extending to the power house.

Feedwater Cycle

Six extraction feedwater heaters raise the temperature of the condensate to its final level of 447 F at the economizer inlet when the boiler is operating at its maximum continuous rating. The three low-pressure heaters for each unit are of the vertical, straight-tube type supplied by the Ross Heater and Mfg. Co. Each of the units also has two Griscom-Russell high-pressure vertical extraction heaters, a Cochrane jet-tray type deaerating heater rated at 750,000 lb per hr, a Griscom-Russell evaporator having a vapor output of 12,000 lb per hr and a Cochrane atomizing-type evaporator deaerator.

There are two motor-driven, seven-stage Worthington boiler feed pumps per unit. Each pump has a capacity of 1800 gpm of 310-F water against a 4000-ft head and is driven by a 2200-hp motor.

As is shown in the heat-balance diagram, the turbine heat rate is 8353 Btu per kwhr with a generator output of 100,309 kw and a condenser vacuum of $1^1/_2$ in. Hg. Calculated station heat rate is 9,900 Btu per kwhr net sendout, based on a boiler efficiency of 88.7 per cent, an average auxiliary power consumption of 5 per cent of gross generation and a condenser vacuum of $1^1/_2$ in. Hg.

Auxiliaries

Saturated steam is used for operation of the condenser tubejet air pumps and for the automatic sequential soot-blower system.

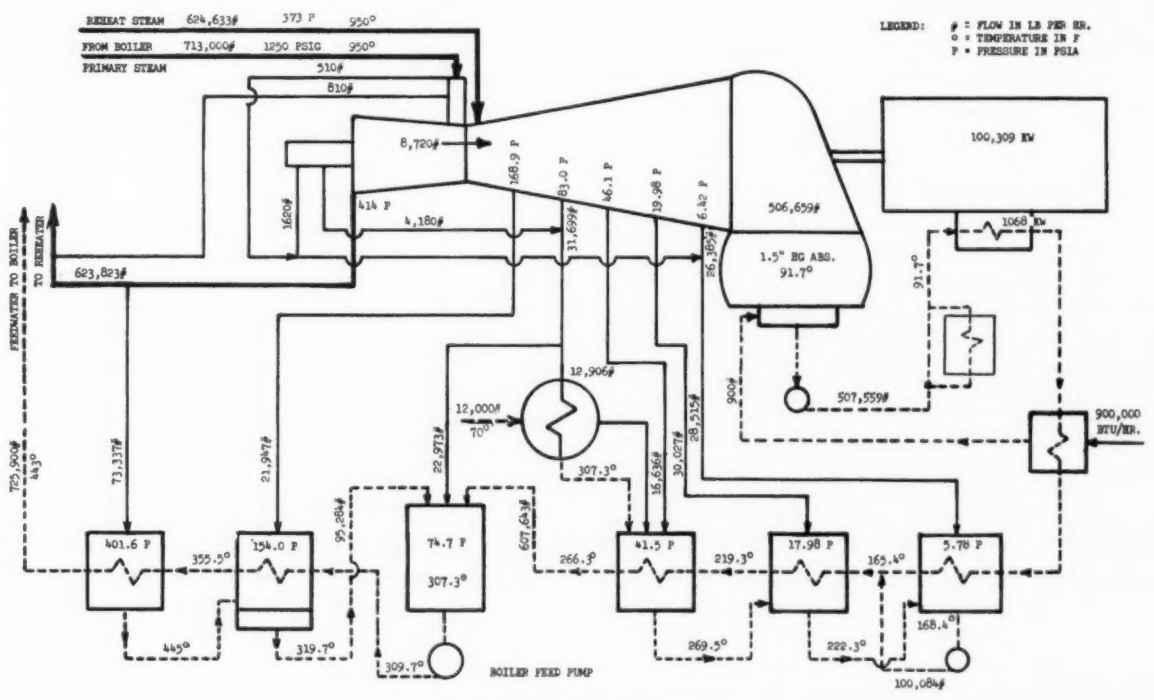
All other auxiliary-equipment units, including turbine auxiliary oil pumps, are motor driven, with 2300-volt, 60-cycle, 3-phase current for all drives above 100 hp. and 550-volt, 60-cycle, 3-phase current for all other motor drives. Direct current at 250 volts is used for emergency and special services.

Piping

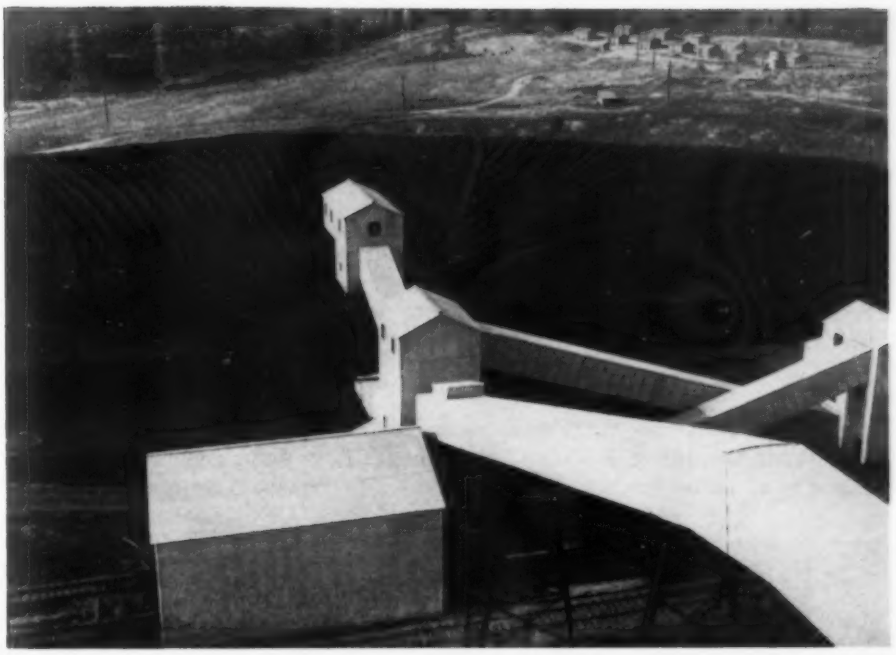
The high-temperature steam piping systems were designed on the basis of 100 per cent cold spring. This procedure was adopted for the following reasons:

(*a*) The maximum pipe stresses will occur when the pipe is cold, and when there will be no stress due to steam pressure.

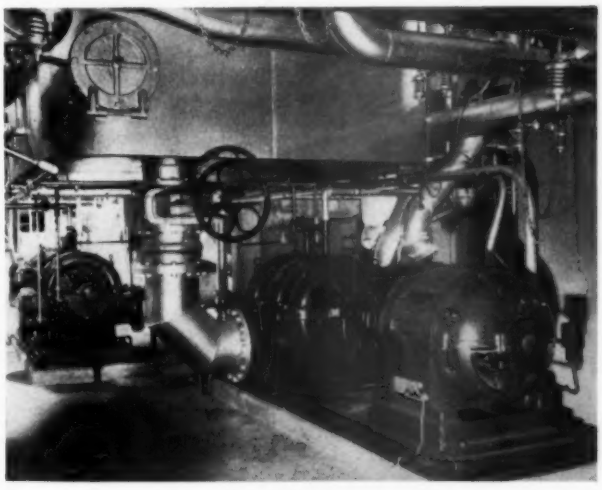
(*b*) The allowable unit stresses on the piping is greater for the cold condition than for the hot condition.



Heat balance diagram
Turbine heat rate = 8353 Btu per kwhr at $1^1/_2$ in. Hg.



Exterior view of coal-handling system and storage pile



Re-entry-type condensate pumps

Boiler panel, central control room

Service water pumps and piping in station basement

(*c*) For the hot condition the piping will have the lowest stresses and thrusts. While the Piping Code permits a maximum credit of only one-third of the maximum stresses, the actual relief of the stresses in the pipe will not be affected by any Code provisions.

No difficulty has been experienced in the erection of the piping with the 100 per cent cold spring.

Provision is made to take care of the vertical expansion of the steam leads in the superheater and reheater elements of the steam generating units. Fabrication and erection of steam and condensate piping was by the Grinnell Company.

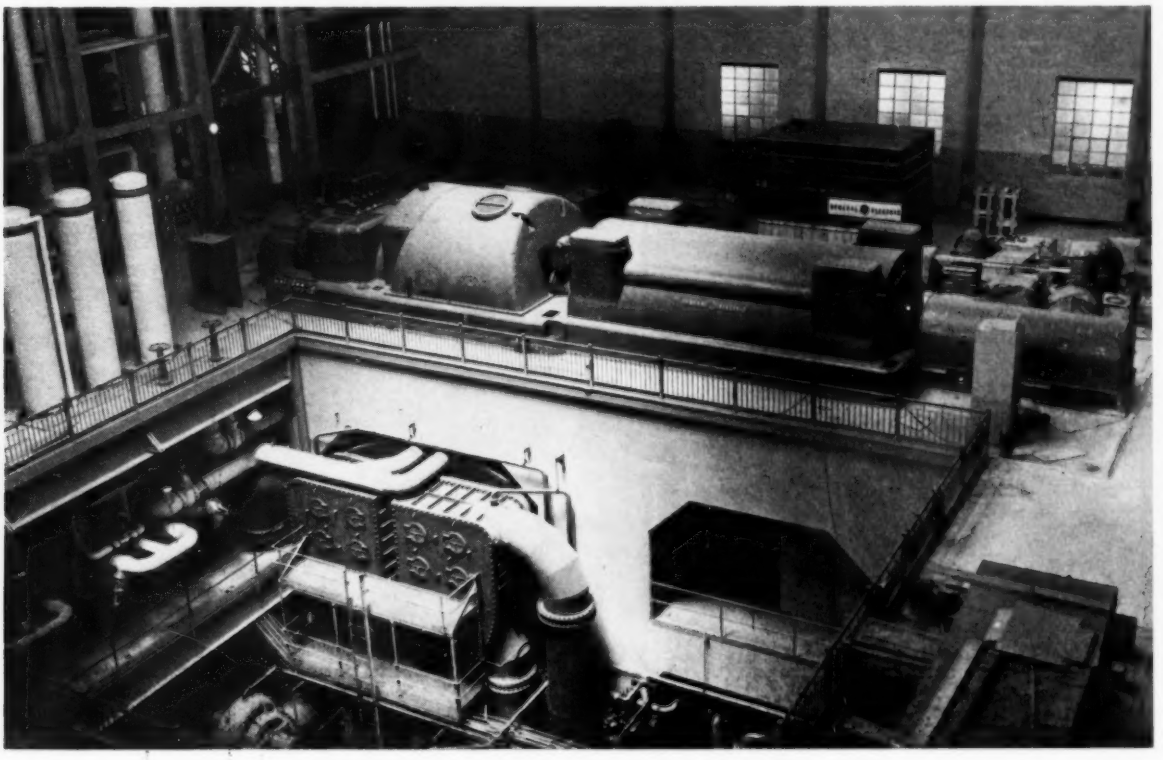
Coal and Ash Handling

Coal is received over the Piedmont & Northern Railway. With the aid of Robins car shakeouts it is discharged to an unloading hopper located under the tracks. It is transported from this point over a system of single belt conveyors at the rate of 500 tons per hour to the crusher house and then to a transfer house, from which point it can be dispatched to a belt conveyor leading to the station or to a conveyor to the storage pile. Bulldozers and carry-all are used to stock out and reclaim the coal. From the reclaiming hopper the coal is carried by a conveyor, which like the others is of Link-Belt design, to the transfer house and on to the station. A Merrick weightometer and a Dings magnetic pulley are located on the conveyor running from the transfer house to the station. In the horizontal conveyor running over the station bunker, a Link-Belt tank-type, self-propelled tripper is installed. A coal-sampling and crushing station is installed in the bunker room.

A stainless-steel auxiliary hopper is located immediately below the bunker outlet and feeds directly into each mill feeder. The hopper is readily accessible from the main operating floor and provides a 20-minute storage of coal for each pulverizer. The elimination of all coal piping between the bunkers and feeders is in line with the Company's established practice and has been found effective in reducing coal stoppages, especially when handling wet coal.

The ash pit hoppers are of the water-filled type, furnished by United Conveyor Corporation. The water for maintaining submergence of the hopper lining is from the discharge of the turbine oil coolers. The hopper is emptied through a single end door and through a clinker crusher into an ash pit located between the two boilers.

Two Nagle horizontal-shaft ash-handling pumps, each having a capacity of 1050 gpm at 143-ft head and driven by a 100-hp, 1200-rpm motor, discharge the ash to a storage area downstream from the plant.



Reheat turbine-generator, Unit No. 1; condenser in foreground; low-pressure heaters on left

The fly ash is removed from the hoppers below the economizer with a Hydroveyor ash conveyor and is discharged through a deaerating tank into the main ash discharge pipe.

Water Treatment

Internal surfaces of the boilers were acid cleaned just prior to initial operation of the units.

The only boiler feedwater treatment used is complete deaeration. Continuous blowdown, generally amounting to from 0.50 to 0.75 per cent of steam flow, is utilized to maintain boiler water concentration of less than 300 ppm total solids and 3 ppm silica. The continuous blowdown is discharged into the evaporator shell where most of the heat and a portion of the water are recovered.

The evaporator feedwater is clarified with an alum-caustic treatment. It is filtered and treated with phos-

phoric acid so that the oxygen and carbon dioxide can be removed in a deaerating heater and the small amount of hardness can be rendered inconsequential. The concentration in the evaporator shell is controlled by continuous blowdown.

Controls

Boiler, turbine and generator controls and all protective relays for the units, for the step-up substation and for the outgoing lines are placed in a centralized control room which is located at end of Unit No. 2 and which is arranged for extension to include future Unit No. 3. Only the operating controls, meters, gages and switches are located in the central control room. The controls for each boiler are grouped on one 8 ft 6-in. long benchboard and one 8 ft 6-in. long vertical panel located 2 ft 6-in. behind the benchboard. The turbine-generator benchboards and corresponding vertical panels, each having a total length of 13 ft, are located parallel with the boiler boards and on the other side of the operating aisle in the control room. The relay boards for each unit are located to the rear of the vertical turbine-generator panel.

The turbine starting instruments are centralized on panels located near the front standard of each unit. Other controls, such as those for a group of pumps, are located in areas near the respective equipment which they serve.

Boiler controls include Bailey automatic combustion control, Bailey three-element feedwater control and Leeds and Northrup automatic steam-temperature control. Diamond Utiliscopes provide the primary indication of boiler drum-water levels through the medium of wired television.

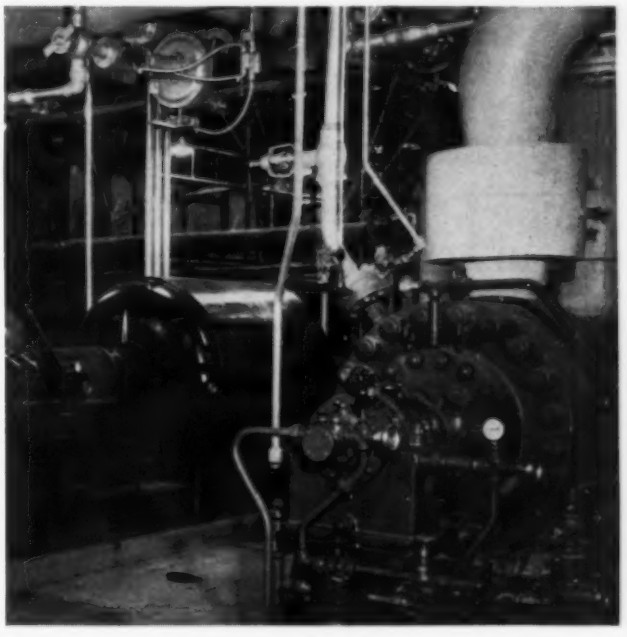
Plant Electrical Features

All switching 13.8 kv and above and all main and auxiliary transformers are located in an outdoor switching station. The essential auxiliaries for each unit are normally supplied from auxiliary transformers connected between the generator breaker and the unit step-up transformers. In the event of failure of the normal power supply the essential auxiliaries are automatically switched to the other unit or to a transmission-line source. Air breakers are used for control of all auxiliary equipment within the station and are housed in metal clad switchgear located in the switchgear room, under the office building which is adjacent to the turbine room on the downstream side of the station.

The plant output is delivered into the Company's extensive transmission network over two new 100-kv and three new 44-kv circuits. In addition, an existing double circuit 100-kv line and a single circuit 44-kv line were looped into the station making a total of six 100-kv and five 44-kv outgoing circuits. Generation is stepped up to transmission voltages through three 62,500-kva, 3-phase, 13.8/105-kv transformers and one bank of three 25,000-kva, single-phase, 13.8/46-kv transformers located outside the station.

Plant Start-up

The turbine of Unit No. 1 was first turned over with steam at 5:20 p.m. on Monday, March 5, 1951. The turbine was gradually brought up to speed and reached the rated value at 2:20 p.m. on Tuesday. That afternoon and night generator and turbine tests were conducted. These were tests normally carried out in the factory but shifted to the field because of unforeseen circumstances. On Wednesday, March 7, the unit was loaded to 45,000 kw, at which time it was found necessary to do some rotor balancing. This work was completed on Thursday evening, at which time the unit was turned over to the manufacturer to check all bearings and to put hydrogen in the generator. The machine was back in service at midnight Sunday, March 11, at which time it was placed in commercial operation. Dump load tests have been conducted on the turbine-generator by dumping loads of 45,000, 70,000 and 90,000 kw. The unit has been carrying 100,000 kw continuously and up to 110,000 kw on peak.



Close-up of motor-driven boiler feed pumps located at basement level

Operation to date has been in line with expected performance, although final heat balance tests have not been completed. There have been no operating difficulties attributable to the reheat cycle.

For the first section of the station, which has a continuous capability of 200,000 kw, six operators per shift will be required. The entire plant personnel, including supervision, clerical, coal handling and maintenance employees, is expected to amount to a total of seventy.

Design, Construction and Operation

The Lee Steam Station was designed by the engineering department of the Duke Power Company under the direction of Mr. D. Nabow, chief designing engineer and was built by the Company's construction department under the supervision of Mr. C. T. Wanzer, division engineer. The plant operation is under the supervision of Mr. E. E. Williams, general superintendent of steam plants.

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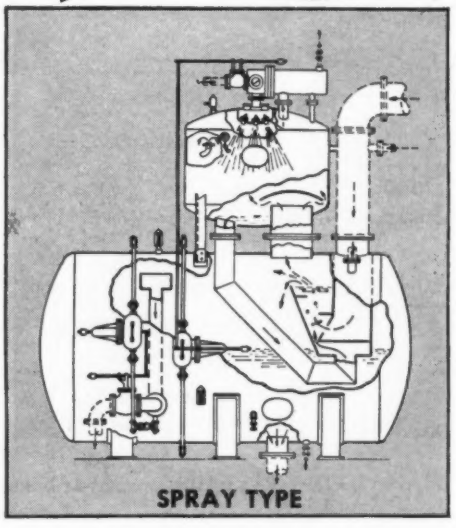
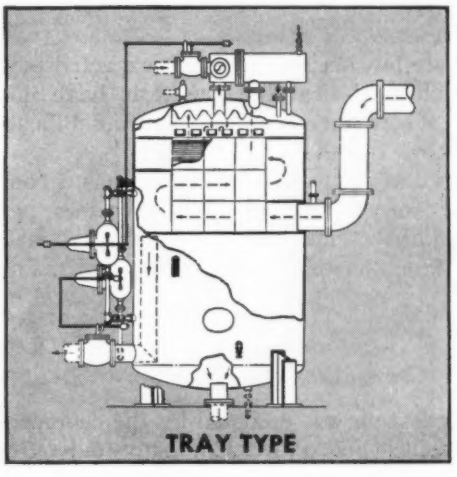


SPRAY TYPE



TRAY TYPE

Here is part of a letter which we recently received from a midwestern engineering firm concerning the performance of a Graver Deaerating Heater installation at a large public institution of which they were in charge.

This spontaneous testimonial is typical of the reports we continuously receive from users of Graver Deaerating Heaters. Whether the units are Spray or Tray type . . . operating on steady or fluctuating loads . . . or with small or large amount of boiler feed make-up . . . a Graver installation can be depended upon to produce zero oxygen and to eliminate carbon dioxide.

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Gamma-Ray Tests of Pipe Welds

By ALEXANDER GOBUS

Metallurgist, Sam Tour & Co., New York

An outline of the procedure employed in examination of field welds by means of radiography with gamma rays as the energy source. Necessary precautions are discussed.

RADIOGRAPHY is a non-destructive means of inspecting fabricated objects. It is in industry what X-ray examination is to the physician.

In the production of the many parts of a modern boiler, or more properly, the modern steam generating unit, fabrication in the shop requires radiographs of many of the component parts. In the shops powerful X-ray machines are generally used; in the field the more convenient and readily portable radium or radioisotope is used. In this article an attempt will be made to describe and discuss some of the features of field radiography.

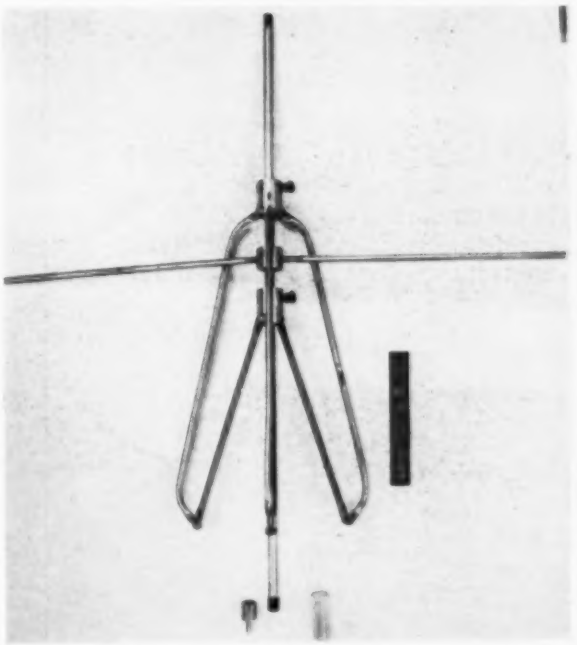
In the course of erection of the modern steam power plant many of the parts, particularly the steel piping, are joined by welding. Such welds are governed almost invariably by rules contained in the A.S.M.E. Power Boiler Code.

Welders employed in this important work must undergo qualification tests which are conducted under carefully prescribed conditions. In addition, a special joint is sometimes made and tested. The latter is a check on the fabricator's design, choice of materials and equipment. The test of the welder is a check on the ability of the individual to produce sound ductile welds under the established procedures.

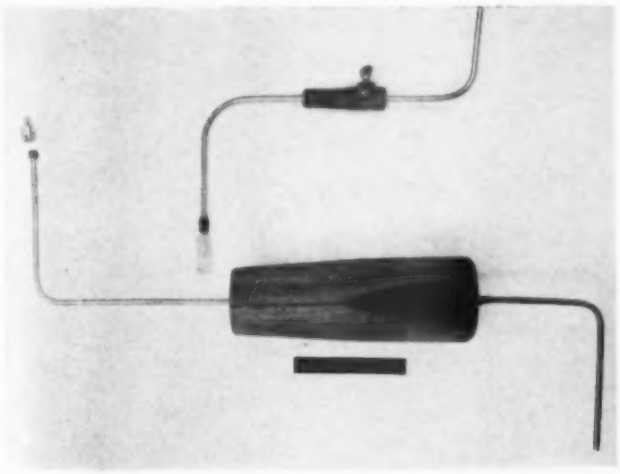
Radiographic inspection by X-rays or gamma rays is and has been used by many industries and most government procurement agencies. The advent of the high-pressure steam unit seems to have been aided by this availability of accepted radiographic techniques. Certainly the ability to inspect by non-destructive means must have done much to guide those responsible for safety to personnel to accept higher and higher service pressures and temperatures.

As previously mentioned, X-ray units are generally used in the fabricators' shops, whereas in the field gamma rays are used. Both sources are acceptable under codes pertaining to steel, brass, bronze and other heavy metals.

The reason for the adoption of gamma-ray sources for field work is that complete portability is attained. Although X-rays are somewhat easier for inexperienced viewers to read, the massive heavy equipment required to penetrate the average field construction weld is not feasible. In fact, the location of the majority of the welds in water and steam lines makes emplacement or focusing of an X-ray tube impossible.



An adjustable fixture to suit pipe diameter where no radium entry hole is provided, as in the case of a field weld of downcomer pipe to drum nozzle. The extension rods act as set-screws for the spacer collar



Typical fixtures used to hold radiation capsule for insertion through hole in pipe; so designed as to permit exact centering. The upper steel container is charged with 150 cm of Co 60. The plastic container is used to hold 50 mgm of radium

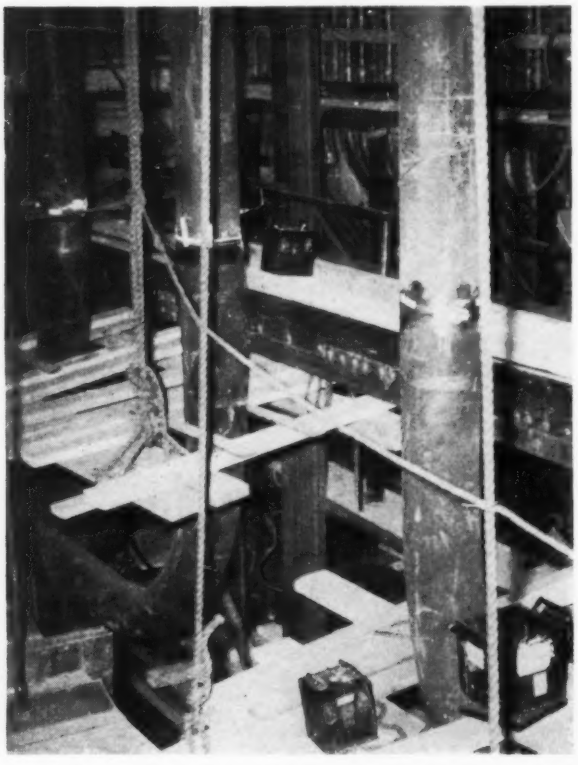
It is fortunate indeed that radium has been available these many years. The pioneering investigations in the 1920's by Mehl, Barrett, Briggs and Gezelius resulted in establishing information which is still used by industry. These data, substantially in the same form as determined in their classic investigations, are still in use. In more recent years the radioactive isotope Cobalt 60 has been made available by the Atomic Energy Commission for

industrial radiography. While there is still much to be learned about its use, it is doing a creditable job in many applications.

To illustrate the portability of a gamma-ray source the following example is given:

Nominal radium units in use vary with the specific application. Such units are generally 50, 100, 200, 300 or 500 milligrams or larger in size. A gram is composed of 1000 milligrams. There are 28.3 grams in an ounce. Therefore, a 50-milligram unit, in plain English, is equal to $^1/_{566}$ of an ounce or about $^1/_{9000}$ of a pound.

Such a unit is furnished as radium sulfate, packed in a silver sphere having an inside diameter of 4 mm (0.158 in.) with a 0.5 mm (0.020 in.) wall. After sealing and aging equilibrium is reached where the rate of decay is equal to the rate of formation. The half-life of radium is about 1580 years. Thus for all practical purposes a constant uniform amount of energy is delivered.



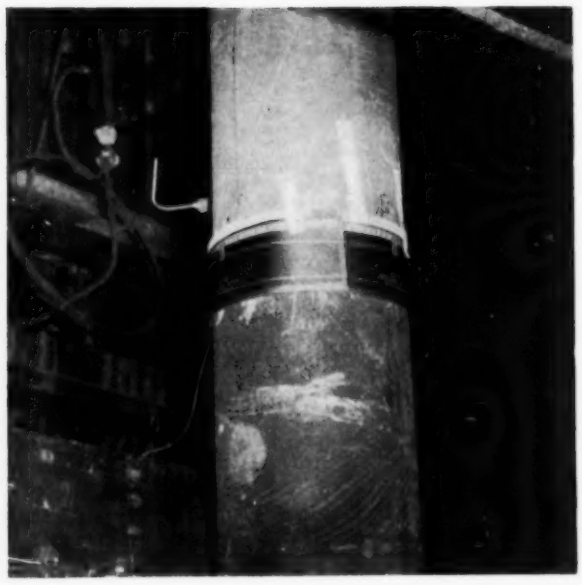
General view of radiographing downcomers

A 50-milligram unit will produce a good radiograph as shown in Table 1.

TABLE 1—TYPICAL EXPOSURE TIMES

From Source of Radium to Film, Inches	Thickness of Steel, Inches	Approximate Exposure Time Type A Film
6	$^3/_4$	90 min
12	$^3/_4$	360 min
9	1	245 min
18	1	980 min
12	2	990 min
24	2	60 hr
12	3	32 hr
24	3	128 hr

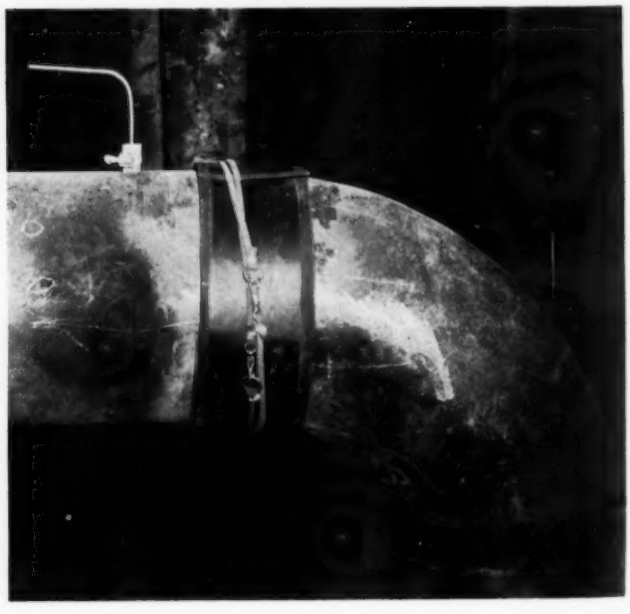
The figures given in the table are not strictly accurate, for variations such as desired film density make appreciable changes in exposure times. They are, however, cited to illustrate the times involved for gamma rays from radium to penetrate solid steel and to produce a latent image on industrial X-ray film. By doubling the source size the exposure time is halved. The relationship between the source size and exposure time is a straight arithmetical function. By using a 500-milligram ($^1/_2$ gram) source, exposure times shown in Table 1 would be divided by ten.



Welded joint being exposed with three overlapping double-loaded 4$^1/_2$ × 17-in. cassettes and radium fixtures in place

The larger the source the faster it works. However, the larger the source the further removed it is from a point source in size and the less sharp the radiograph, all other factors remaining constant. Therefore, it is desirable that gamma-ray radiography be done only by those fully familiar with all of the factors involved. This is especially true where Power Boiler Code P-102 requirements (or other specifications such as UW 51, Unfired Pressure Vessels, W 524—A.S.M.E., API, U. S. Coast Guard and other codes) must be met.

Cobalt 60, as now generally furnished, has about 1$^1/_2$ times the strength of a capsule of radium of the same volume. Hence it is commonly said to be more powerful



Showing placement of capsule and cassette in radiographing elbow weld

than radium. This is true of a newly purchased unit. Since the half-life of Cobalt 60 is only 5.3 years it must be recalculated each 6 months as the equivalent of a new source. The energy delivered per unit volume, therefore, is not constant. After long enough aging it becomes equal to or less than that of radium in energy delivered per unit volume.

Care in Handling

The handling of radioactive materials and X-ray units must be done by personnel having several skills. These skills include the training required in planning for an exposure, and the experience required for operating a photo dark room. The operator should have an objective attitude. A predetermined health standard as approved by a qualified medical specialist is also essential. Such personnel must thereafter follow some self-monitoring practice plus some system of periodic check-up examinations by the medical specialist. While they may seem formidable, these simple precautions, coupled with proper rapid (not hasty) handling, are required for adequate protection. No case of radiation damage to properly trained industrial personnel has come to the writer's attention in 20 years of close association with radiation work.

Paragraph 102, Section h (1 to 10) of the A.S.M.E. Power Boiler Code gives a complete description of radiographic requirements. Some of the essential requirements are referred to herewith together with an explanation as to how actual gamma-ray radiography is applied.

102 h 2—Removal of Weld Ripples Backing Rings

The usual method of removing weld ripples is by grinding, taking care to merge the crown smoothly with the pipe.

The backing ring should be wide enough so that the image of its edges projects well beyond the furthermost edges of the deposited weld metal. This design eliminates the peril of misinterpretation of the radiograph such as is apt to happen where a narrow ring is used. Some fabricators use a narrow ring and under certain conditions the resulting radiograph can be misleading.

102 h 3 (a) Penetrameters

Penetrameters are indicating devices placed at the source side of the set-up during exposure to indicate in the finished radiograph that the technique used has been satisfactory. That is all that is determined by their use. There is no guarantee that a perfectly applied radiographic technique has detected every possible defect. This is true of some defects that exceed two per cent of the section.

While a good radiograph generally will show all of the harmful discontinuities the possibility of an undetected crack or crack-like defect lying in a plane at an angle to the radiation beam must not be ignored.

102 h 4—Exposure Distance

This section of the Code refers to two important details of technique.

The requirement that the film shall be as close to the weld as possible but in any event not more than 1 in. from the weld is an excellent precaution. Good radiographic quality is lost with unnecessary projection of the image.

All penetrameters and other markings must be located before exposure is started. *Section 102 h 6* lead numbers and letters are used to designate the fabricators name or symbol, the unit numbers being made, the contract number, the welded joint number and station locations at uniform increments around the pipe periphery.

While the Code states that location designation shall be permanently stamped on the object, most fabricators prefer to forgo this requirement so as to avoid risk of notch effect injury. In lieu of this accurate records are made.

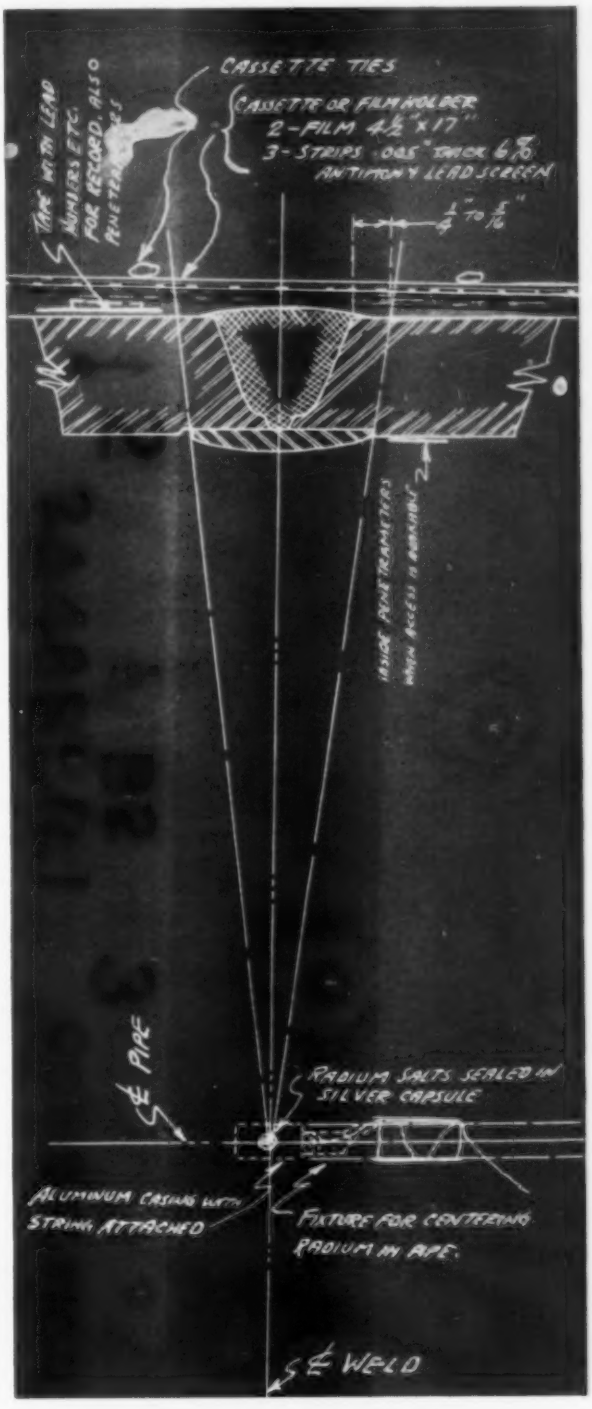


Diagram of setup for radiographing

Suitable sized films are loaded in duplicate in flexible film holders called cassettes. X-ray film is coated with

Fixture for hot radiography with one cassette in place. Note water-cooled jacket

its sensitive emulsions on both sides. In order to enhance film quality and to reduce exposure time thin lead screens are used. This means that two films are placed between three lead screens so that each side of each film is in contact with the lead which is usually 0.005 in. in thickness.

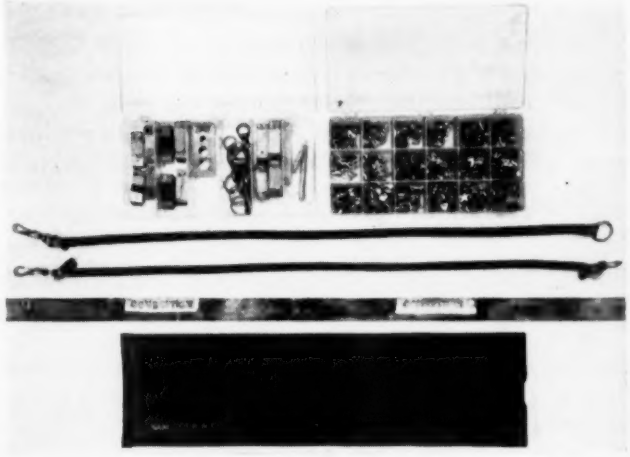
Exposure may be made by placing the radiation source within the pipe through a radium entry hole. Such a hole as placed by some fabricators is 1 in. in diameter. It is threaded with a special thread so that there will be no danger of a cast-iron pipe plug being inadvertently inserted when the time comes to seal it.

A satisfactory arrangement is to have the center line of the radium entry hole 6 in. from the center line of the weld. Smoothly contoured fixtures fit such a scheme admirably.

Upon completion of exposure the cassettes are unloaded in an X-ray dark room and the film is then fastened in special developer hangers and processed in X-ray processing tanks holding X-ray developer and fixer. Developing is best done at 68 F. Double the developing time recommended by the manufacturer of the developer for X-ray developing is used for gamma-ray exposures.

It is important that X-ray film be processed as described. Any attempt to develop in trays or other makeshift devices invariably leads to enough film damage to render interpretation difficult or impossible.

When films have been dried and assembled in logical order the responsible inspection agency should be called in for viewing and approval.



Equipment used in radiographing

Of recent interest is the invention of the method known as the McElroy-McNutt process of Hot Radiography (patent applied for).

It has often been desirable to take a radiograph of objects at elevated temperature; but heretofore it has been impossible to take a radiograph if the metal was at 120 F or hotter. With this new development available satisfactory radiographs are being made in field work at 600 F and have been taken in special cases at 1500 F.

A specially constructed close-fitting water-cooled jacket is placed between the hot object and the film, and running water is circulated through the jacket. The exposure is then made in the usual manner.

Radiography has extensive use in many other places in and around steam generating stations.

In conclusion, it may also be mentioned that radiography is a firmly established inspection method in marine and land installations, and it should be repeated that proper care must be observed in the handling of radiation of all sorts in so far as hazards to personnel are concerned. The author wishes to acknowledge the helpfulness of John H. Hunt of Combustion Engineering-Superheater, Inc. for suggestions and reviewing the text.

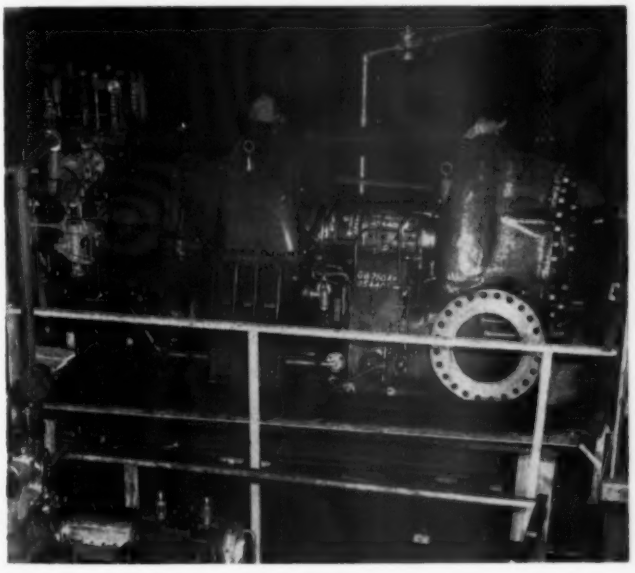
Chipping out defects found by gamma-ray inspection

Steam Turbine Drive for Gas Line Pumping

The wide extension of natural gas pipe lines over this country has necessitated many high-pressure booster pumping stations. For such service gas-engine-driven reciprocating compressors predominate, although there are an increasing number of centrifugal compressors being used. Such compressors now have efficiencies exceeding 80 per cent, and they can be operated at maximum efficiency over a wide range in load. Where electric rates are sufficiently low, they have been motor-driven, but recently steam-turbine drive has made its appearance. The steam turbine is capable of speed variation; thus flexible operation is possible.

Proponents of centrifugal compressors for gas line pumping also point to the low initial cost, continuous and nonpulsating flow, low maintenance, good efficiency and reliability.

The Transcontinental Pipe Line System is engaged in building an 1800-mile line to transport natural gas from Texas to serve various localities along the Eastern Seaboard, which involves nineteen pumping stations spaced some 80 miles apart. Of these, three stations will employ steam-turbine-driven centrifugal pumps, operating at 4500 rpm. That located near McComb, Mississippi, will have three De Laval turbine-driven compressors operating in series. There will be no spares. Should it become necessary to take one of the compressors out of service for a short period, the other two can handle the work at slightly less efficiency by speeding up. These compressors, which are mounted on the same bed plate as the turbine, boost the gas pressure from 518 psi to 819 psi. The three units will deliver over 600 million standard cubic feet per day. Each of the turbine units is rated at 5000 hp and operates condensing.



One of the 5000-hp turbine-driven compressors on test

The complete installation will also include two 800-kw De Laval geared turbine-generators for station service, such as motor-driven auxiliaries and lighting. Their exhaust at 20 psig back pressure is used for feedwater heating. Steam is supplied at 625 psi, 750 F by three gas-fired boilers.

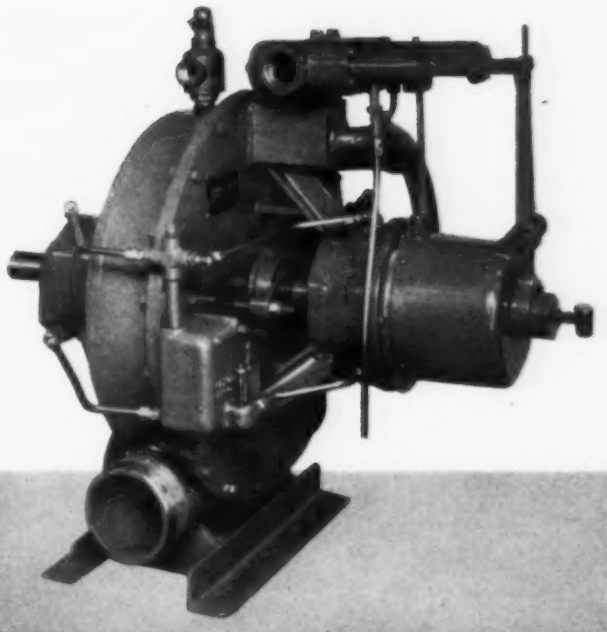


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Fig. 19084 W. E.—Class 900-pound Cast Steel Pressure Seal Globe Non-Return Valve with welding ends and gear operation. Improved streamline design reduces pressure drop and turbulence to the minimum.

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Design of Large Modern Stacks

By G. V. WILLIAMSON

Supt. of Steam Engineering,
Union Electric Co. of Missouri

This discussion presented at the recent Annual Meeting of the Air Pollution and Smoke Prevention Association of America, Roanoke, Va., highlights some of the problems confronting the designer of large, high stacks, as well as problems of the plant operator in maintaining stack lights, inspection and maintenance. Masonry versus steel stacks are considered at some length.

PROBLEMS facing the designer of a stack for a modern power plant are many and include the following:

1. Selection of range of future fuels; estimate of maximum boiler capability; provisions for adequate excess air used in combustion; allowance for air infiltration, and estimates of gas temperatures, which will determine the weight and volume of flue gas.
2. Determination as to whether the stack shall serve one or more boilers.
3. Determination of stack position – roof or ground level, and resultant foundation economics.
4. Calculations of effect of stack diameter and gas velocity on draft obtained versus draft fan size and stack cost. Allowance in fans for possible future change in exit velocity.
5. Collection of experience data on maintenance of steel versus masonry stacks to assist in the choice.
6. If steel, choice of alloy, thickness, etc., and general proportions—whether straight or tapering.
7. If masonry, choice of radial brick, concrete or hollow tile with reinforced concrete fill.
8. Decision on lining to be used and extent, partial or full height.
9. Foundation design, possibly with provisions for future greater height.
10. Design of cap for avoiding fly ash collection; and lightning protection, if masonry.
11. Provision for cleaning and future stack inspection by ladder or other means.
12. Lighting of stack top and sides for aircraft warning and provisions for maintenance of lighting.

It is obvious that allowance must be made for a full range of probable fuels and that calculated exit gas velocity is dependent on this. Estimates must be made of the gas temperature entering and leaving the stack, the boiler capability in heat demand and quantities of excess and infiltering air. Both maximum and minimum assumptions must be followed through most subsequent calculations to indicate all the effects.

Modern American practice favors a separate stack for each boiler when the latter is large and serves a single turbine-generator of the order of around 100,000 kw or larger. Considerations of exit gas velocity particularly lead to this trend since there is the problem of satisfactory velocity at say half load which would mean a four-to-one problem on a two-boiler stack with one boiler idle. Inasmuch as individual boiler sizes now appear feasible up to 200,000 kw, this would mean that no more than an ultimate four stacks would probably be required at any one location.

Another definite trend in recent large power plant design, where ground area permits, is toward the "ranch-house" arrangement, particularly when fans and dust collectors require more space than roof areas can conveniently accommodate. In the "ranch-house" arrangement this equipment is at ground level, thus increasing stack height (not top elevation) but simplifying building steel design and attendance of fans and dust collectors. While roof-top stacks on new plants are by no means uncommon the advantages appear once again to favor ground stacks.

The next steps in stack design call for consideration of stack diameters, as independent of throat restrictions at the exit. Here maximum gas volumes must be accurately determined, and the economics of gas friction and fan power balanced against construction costs.

Steel vs. Masonry Stacks

Choice between steel, radial brick, tile and concrete stacks involves a balance between first cost and lifetime maintenance, plus the realization of carrying charges on the first cost. Unfortunately, the designer is often severely limited in his knowledge of maintenance costs. Experience in our system has covered radial brick, tile and steel stacks. It is our opinion that a lined steel stack will cost less to maintain over a 20- to 40-yr period. Masonry stacks show almost no maintenance for the first 10 to 15 yr, but when it is required, it can be extremely heavy. A roof top masonry stack may cost more to dismantle than to erect. Also, a masonry stack can be difficult to inspect since steeplejacks generally do not trust ladder-rung loops set in mortar, but will trust a separately supported ladder such as may be provided on a steel stack. Permanently mounted ropes and pulleys, cannot be depended upon for boatswains' hoists after the first two or three years. To scale a 15- by 250-ft stack for inspection, by bands and scaffold, may cost $1000. Inspection facilities, then, favor a steel stack.

The matter of lightning, and of frost action when a stack is idle, may be strong factors in the choice between

steel and masonry. In steel stacks corrosion, of course, and internal erosion by ash of unlined portions are the problems. It is a moot point whether steel stacks are painted for external corrosion prevention or for appearance, but in any event painting is necessary.

First cost, whether steel or brick, has been found to be remarkably close to $100,000 for the stack and foundation serving a large unit. Hollow tile with concrete filling would cost considerably more. The straight reinforced-concrete stack is probably more dependent than the others on scrupulous care in details of design and construction. There are those who believe they can build a long-life concrete stack, and those who doubt it. Our latest choice is for a steel stack, untapered except for the first 50 ft.

There are details of cost estimate which may not readily occur to the designer. One such item is that of wind loading. This will be greater on masonry stacks which normally taper from top to bottom and, therefore, offer more area for wind resistance, which is a matter of great concern as to foundation design. The greater weight of masonry may be a factor for a stack supported on piling. If the decision is to avoid uplift piling, for example, extra concrete base may be needed for a steel stack. This can be particularly "tricky" in allowing for future additions to stack height should that later become mandatory. Experience indicates that the less foundation required for steel stacks on the ground may mean 10 per cent less on the whole cost of the stack. About 10 per cent would be added to the cost of the steel stack if it were tapered for appearance.

Use of low-chrome copper-alloy steels, highly resistant to corrosion, is of interest. They may even result in a lower cost stack if the designer is ready to accept thinner plate because of its greater strength. On the other hand, the designer may decide to use no plate less than $^5/_{16}$ in., in which case low-alloy steel may add 5 per cent to the cost, and yet be well worth while in a corrosive atmosphere.

All-welded construction for large steel stacks seems to be now almost universal. For these, V welds are usually employed, occasionally with retainer rings outside, and a T rim to the interior which becomes a support for lining.

Stack Linings

Stack linings serve three purposes, namely,

1. They protect the outer stack from gas corrosion or erosion.

2. They help hold up the temperature of the gas, giving more buoyancy in the atmosphere, and hence, cause the plume of the discharged gases to rise higher and thus disperse better.

3. They reduce the extremes of temperature on the outer stack, and cause less strain and temperature cracking on shutdown in cold weather. There has been considerable success with gunite linings in the St. Louis plants. This is usually applied directly about two inches thick to a steel stack with suitable holding studs and mesh, alumnite cement and haydite aggregate. Such lining has remained sufficiently intact and in close enough bond with the steel, when carefully applied, to avoid leakage of gases between the lining and the steel. Leakage of gas behind the gunite would cause severe corrosion and must be avoided.

With an uneven terrain or in an area where tall buildings may later be constructed, a chosen stack height may subsequently require increasing. Recent experience indicates that atmospheric inversion may also lead to a change in desired stack height. Again, future regulations imposed by air pollution control officials may make a 50- to 60-ft addition desirable. Provision for such a contingency proves quite expensive for the following reasons: It adds to the initial steel weight and consequent foundation cost; it sharply increases the wind load on windward side piling, and results in uplift on lee side piling that may require a considerable mass of concrete to offset, and hence still more load piling, and most of the ultimate foundation must be provided in advance. Such adverse factors indicate the care which framers of regulatory legislation should take in applying new regulations to old plants.

A common hazard from stacks on older pulverized-coal installations results from the accumulation of ash coning up on the top edge, and then dropping to the roof or ground below in large chunks. This can be met by a cast iron cap, carried to a sharp edge, vertical on the outside and sloping toward the center.

A shaped cone insert for increased velocity at exit can be of formed steel, but a shaped gunite throat is being considered because of the present unavailability of stainless steel, as well as the lower cost.

Masonry stacks require rigid lightning rod protection. This may be expensive to maintain because of corrosion and difficulty in reaching the stack top. Over two-thirds of the damage to six, 400-ft masonry stacks in the St. Louis system was traced to lightning cracks, despite rod protection. Twenty feet of these stacks had to be removed to get below the damage. On the other hand, steel stacks are virtually immune to damage from lightning.

Ladders for scaling tall stacks offer some difficult problems for the designer and plant operator, particularly on masonry stacks. As previously mentioned, professional steeplejacks generally refuse to use ladder steps cast into the mortar or concrete of masonry stacks over 5 to 10 yrs of age since one loose step jeopardizes a climb. A separate ladder with steel risers is preferable if the stack is not over 150 ft. Above that hazards are again a psychological factor. Bronze pulleys at the top soon corrode. Scaling a large diameter masonry stack by taut circular cables and leap frog platform is the common solution, but expensive and slow. It probably will require a week for each 100 ft for a skilled three- or four-man crew. Binocular inspections are not dependable. Installation of safe ladders on steel stacks is a somewhat simpler process than on masonry stacks.

A final problem warranting discussion here is that of lighting the stack at night for warning to aviation. The installation of lights is simple but replacement of burned out lamps is a problem, so severe that some operators prefer floodlighting from below. Floodlighting, however, may be objectionable near residential areas for aesthetic reasons, and has the unfortunate tendency at night to strongly highlight a plume that is barely visible in the daytime.

A promising pulley rig for raising and lowering lights to and from a stack top is now available. It remains to be seen if it will hold up under corrosion conditions which prevail.

Facts and Figures

The world's tallest chimney is 611 ft.

●

The American coal miner produced an average of nearly seven tons of coal per working day during 1950.

●

Aluminum is the world's most abundant metallic element and forms approximately one-twelfth of the solid portion of the earth's crust.

●

Some of our latest steam stations are producing a kilowatt-hour on less than three-quarters of a pound of coal.

●

Fly ash from pulverized coal-fired boilers is usually of such fineness that at least 70 per cent will pass through a 325-mesh screen.

●

During the first quarter of 1951 military requirements took twelve per cent of the total steel production in this country.

●

It is reported that nearly three-quarters of the boilers sold in Sweden since the war have employed controlled or forced circulation.

●

Despite the widespread use of disel-electric drive, the railroads use approximately 13 per cent of the bituminous coal mined in the United States.

●

Because of the high hydrogen content of natural gas, the overall efficiencies of boilers burning such fuel is 3 to 4 per cent lower than if coal were burned in the same units.

●

If the tubes of a tubular air heater for a modern large capacity steam generating unit were to be placed end-to-end, they would extend from New York to just past Philadelphia.

●

According to Bituminous Coal Institute, the Soviet Union's total coal production in 1950 was less than the combined total output of bituminous coal in Pennsylvania, West Virginia and Illinois.

●

The first steel rails to be produced in this country were turned out in 1865, according to a recent statement by Secretary of Commerce Sawyer.

●

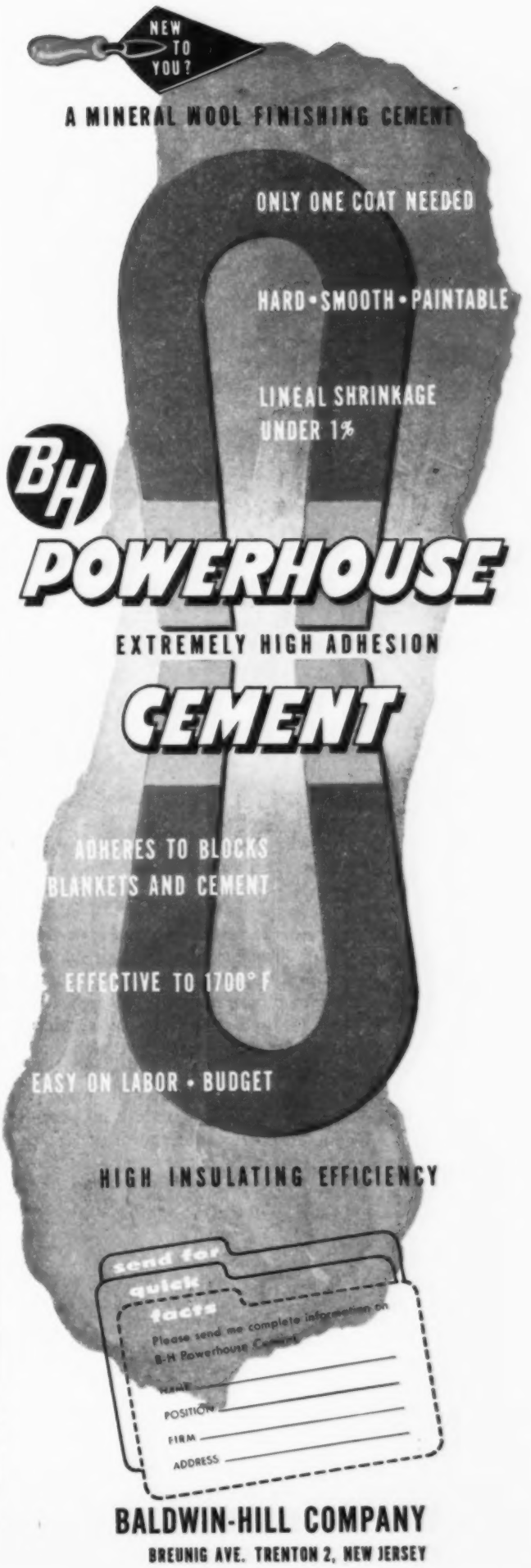
Production of electric energy by utilities in the United States for the month of March was nearly 31 billion kilowatt-hours, making that for the twelve months ending March 31 over 341 billion kilowatt-hours, as compared with 296 billion during the like period ending March 31, 1950.

●

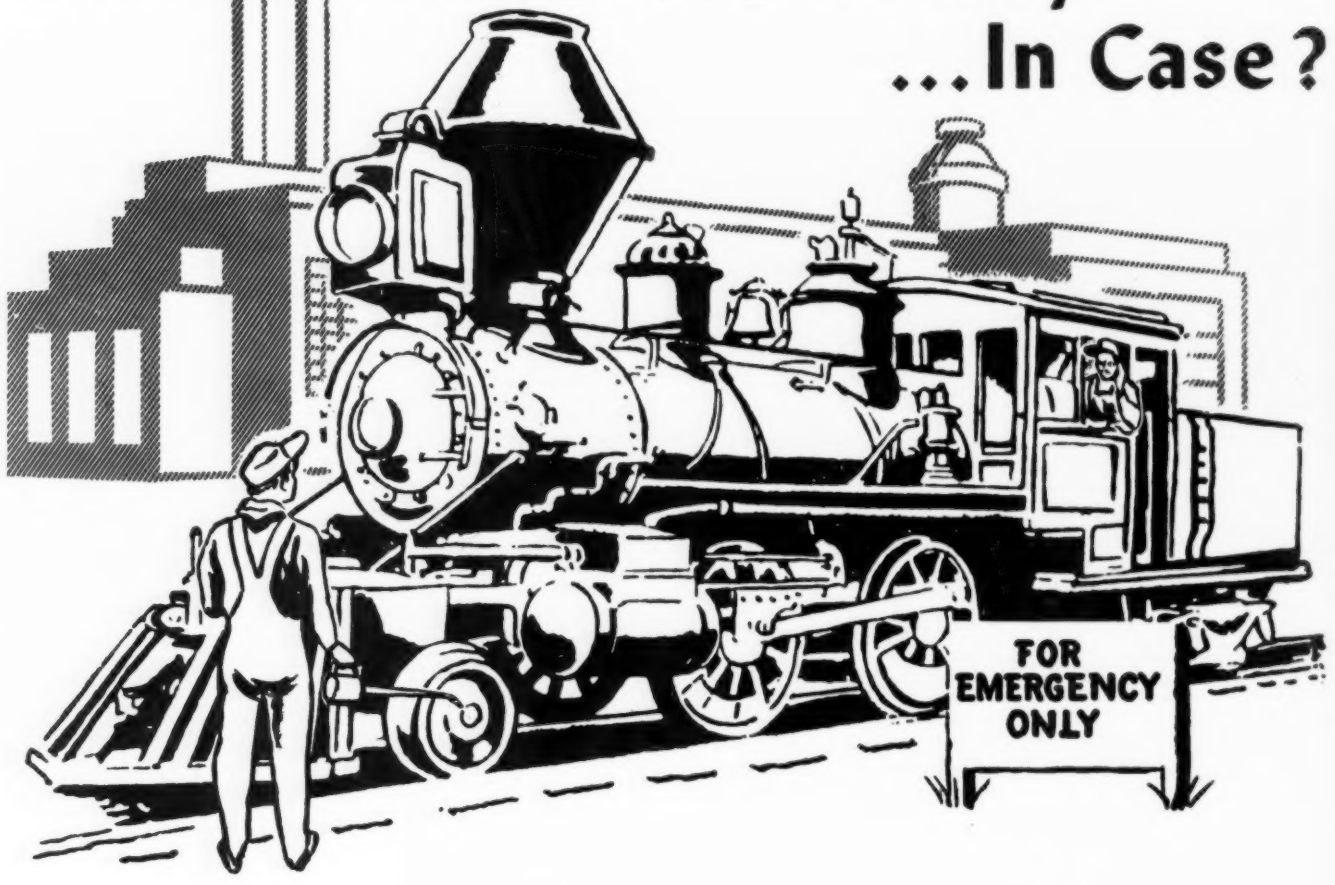
Public Service Electric & Gas Company has ordered from Westinghouse a 185,000-kw tandem-compound turbine-generator for its Burlington, New Jersey, station. This unit is said to be the largest single-shaft 3600-rpm machine yet projected.

●

High output by the nation's steel mills has created a desperate need for scrap, as a result of which the National Production Administration has launched a campaign to collect 32 million tons of steel scrap for consumption during the current year.



Got a Locomotive Handy ...In Case?



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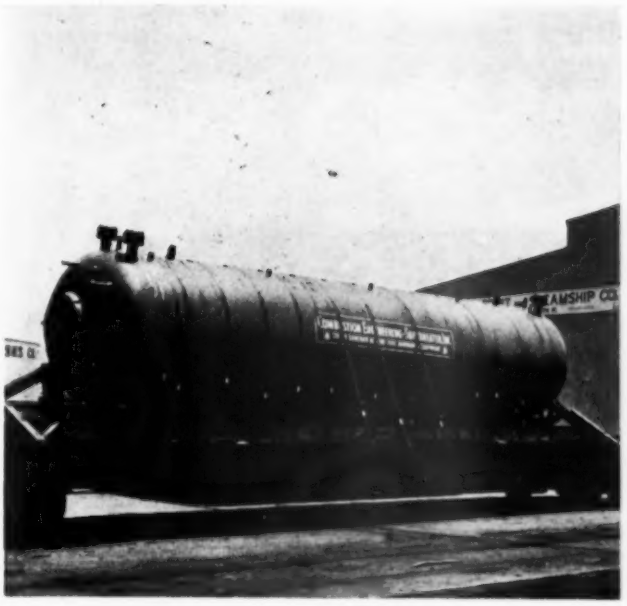


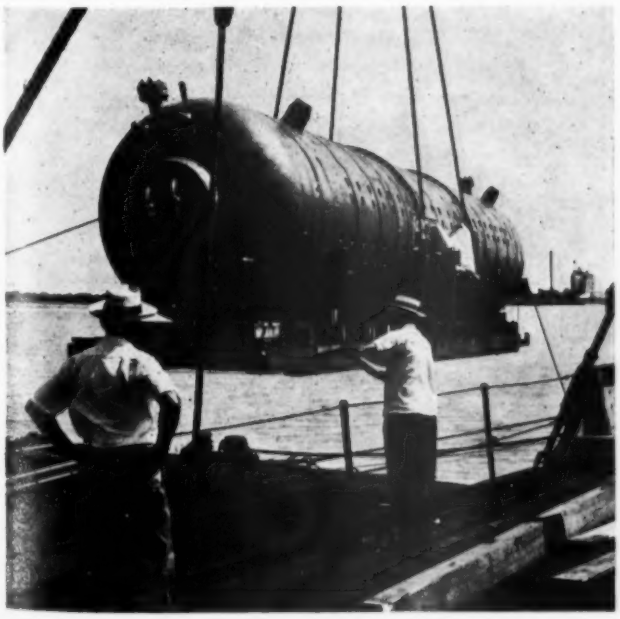
Large Boiler Drum en Route to France

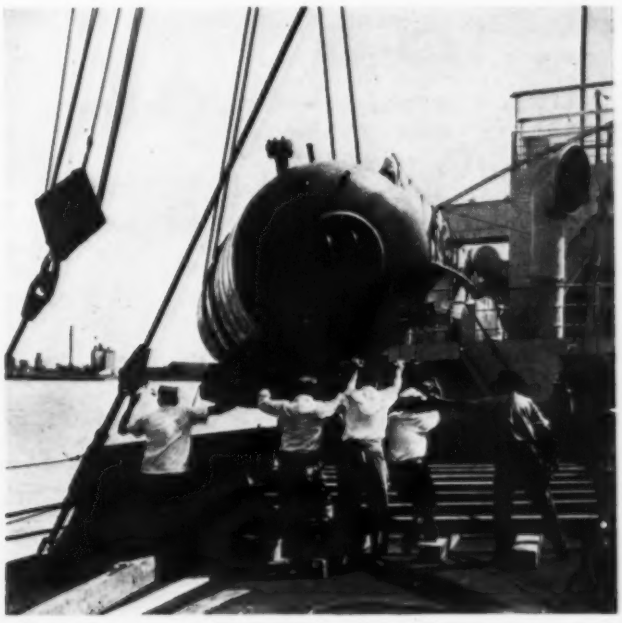
This sequence of photos taken in New Orleans, La., shows the loading aboard the "Bayeux" of a fusion-welded steam drum for one of two steam generating units being built for the Nantes-Cheviré Power Station of the Electricité de France. The drum, fabricated in the Chattanooga, Tenn., shops of Combustion Engineering-Superheater, Inc., is 72 in. in diameter, 33 ft 4 in. in length, and weighs more than 65 tons.

Economic Cooperation Administration funds are being used for the first portion of this station which will have an ultimate capacity of 500,000 kw. At the present time two 50,000-kw turbine-generators and two boilers, each rated at 500,000 lb of steam per hour, are being installed. Superheater outlet conditions are 1330 psig and 986 F.

Combustion Engineering is responsible for the design of the steam generating units and is supplying the principal pressure parts and tilting tangential burners for coal firing. Stein & Roubaix, its associated French company and licensee, is furnishing the mills, oil burners and other component parts assisted by Chantiers and Ateliers de Penhoet, one of the important shipyards in St. Nazaire. Because dollar funds are available to cover the equivalent of only one boiler, the first steam generating unit is largely of American construction, while the second is primarily of French construction. Consulting engineers on the American phases of the project are Gilbert Associates, Inc.

The Nantes-Cheviré Power Station is being constructed on Loire River a few miles from St. Nazaire.





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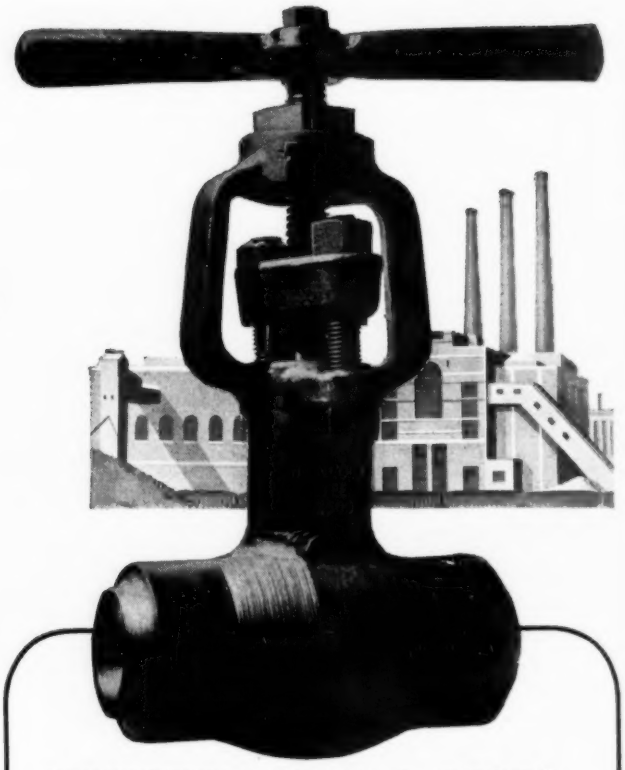

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Power Generation by Gas Turbines*

By A. G. MELLOR

General Electric Co., Schenectady, N. Y.

GAS turbine units at present commercially available are relatively small in output rating. Detailed design and operating characteristics of two of the units being produced by the Company with which the author is associated have been published in the technical press, hence only a few details will be given here.

The first of these units is a 3500-kw, single-shaft, simple-cycle machine which was originally designed for locomotive use and later adapted for central station power generation. This unit has been rated 4000 kw when operating on natural gas but until further experience is obtained will be rated 3500 kw when operating on Bunker C oil. Its thermal efficiency at 3500 kw is approximately 15 per cent, based on the higher heating value of Bunker C oil, and is somewhat higher when operating at 4000 kw. Cooling water requirements are very small, being only that required for generator and lubricating oil cooling. In locations where water is scarce or difficult and expensive to obtain, these cooling requirements could be taken care of by air coolers. This unit is rated at 80 F ambient air temperature and, like other gas turbines, is subject to variations in available output with changes in air temperature. Increased output is available at air temperatures below 80 F while above this temperature the output must be reduced. For operation in areas where high ambient air temperatures are common, it may be economical, if sufficient water is available, to cool the incoming air by evaporative cooling or by surface air coolers.

The second gas turbine developed is a 5000-kw compound-cycle, two-shaft unit, with intercoolers and regenerators, resulting in a thermal efficiency of about 26.3 per cent based on the higher heating value of Bunker C oil. The two-shaft design, allowing the low-pressure compressor speed to vary with load, results in much improved part load efficiency, comparable to that obtained with a steam turbine. In addition to the cooling water required for generator and lubricating oil cooling, about 800 gpm is required for intercooling. This is about two-thirds to three-fourths of the cooling water requirement of a comparable diesel engine and only about one-fifth to one-sixth of that required by the same size of steam station. It is equipped with variable-angle inlet guide vanes on both the low-pressure and high-pressure compressors to compensate for changes in ambient air temperature and altitude. This permits the unit to carry rated load, at a slightly higher fuel rate, at ambient air temperatures up to 110 F. At ambient air temperatures below about 60 F it can deliver up to 6250 kw.

* From a paper before the Midwest Power Conference, Chicago, April 4–6.

Since the gas turbine has reached a state of development where it can be applied in power generation as an alternate to other older established prime movers, it is the purpose of this paper to point out some economic comparisons between various types of generation and to indicate the most probable fields of application for gas turbines.

A third gas-turbine has more recently been developed which is rated 3500 kw but incorporates a regenerator and is a two-shaft design. The thermal efficiency is about 22 per cent based on the higher heating value of Bunker C oil and, as in the 5000-kw compound cycle unit, the two-shaft design results in good part-load efficiency. Cooling water requirements are practically the same as for the 3500-kw simple-cycle unit.

All of these units can burn either natural gas or Bunker C and diesel oil. At present, to change from gas to oil fuel, or vice versa, requires a shutdown to change some of the fuel system components. Development work now under way should result in a great reduction in the time required to convert from one fuel to another and it may become possible to do this while the unit is carrying load.

Gas-Turbine Generating Stations

In addition to the gas-turbine unit, a complete gas-turbine generating station requires a fuel supply system, a cooling-water system, an auxiliary power system and the normal main power connections and switchgear.

Gas turbines that are normally operated on Bunker C oil must be started and shut down on diesel oil. For such units it is, therefore, necessary to provide a diesel fuel system as well as a Bunker C fuel system. Bunker C oil must be heated and centrifuged before being delivered to the gas-turbine-driven fuel pump. To ensure reliability, pumps, heaters and centrifuges should be installed in duplicate.

The fuel system required for a gas-fired gas-turbine station is very much simpler than for an oil-fired station. The only equipment required is a pressure regulating valve and possibly a fuel gas compressor if the fuel is not available at a sufficiently high pressure for use in the gas turbine.

A reliable supply of auxiliary power must be available for starting gas turbine units. In most cases this can be obtained from the power system but in a few cases where a unit is located at the end of a single transmission line it may be desirable to provide an engine-driven generator to supply starting power and station auxiliary power in case of transmission line outage. The amount of power required for starting the unit is relatively large compared with the auxiliary power required when the unit is running and so the starting requirement determines the size of the auxiliary power transformer or the engine-driven auxiliary generator.

In general, the electrical equipment used in the auxiliary power system and in the main generator outgoing circuits is of conventional design and does not differ from that used in other types of generating stations.

As might be expected, since the three units previously described are of different design and different efficiency, they vary in cost per kilowatt of output, and this is reflected in the overall station cost. The following tabulation shows estimated costs for complete generating stations using these three types of gas turbines. These costs per kilowatt are based on the nominal ratings of the units and not on the maximum output available under favorable operating conditions.

Kw Rating	Cycle	Approx. Heat Rate on Oil (Higher Heating Value) Btu/Kwhr	Approx. Cost per Kw
3500	Simple	22,900	$155
3500	Regenerative	15,500	$195
5000	Compound	12,950	$215

Operation of Gas Turbines

A control has been developed which provides for semi-automatic starting and stopping of the unit, for speed and load control and for protection of the unit under abnormal operating conditions or in the event of mal-functioning of any component part. This relieves the operator of much of the responsibility for operation and makes it possible for one operator to supervise one or more gas turbine units. It is realized, however, that most operating companies might insist on having two operators present in the station at all times.

In the design of this control the possibility of building completely automatic, unattended gas-turbine generating stations was taken into consideration. The modifications and additions required for an unattended gas-fired station are minor but an unattended oil-fired station presents some additional complications mainly in the fuel handling, heating and centrifuging equipment required for Bunker C oil.

A gas-fired gas-turbine generating unit has now been in practically continuous operation for about 20 months with only negligible maintenance expense. This experience indicates that maintenance on gas turbine units, when operating on this fuel, will be considerably less than on comparable sizes of either diesel or steam turbine

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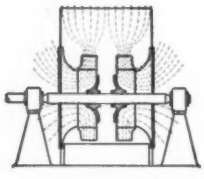
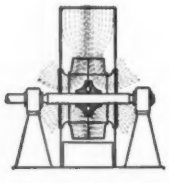


How P-D split wheel assists diffusion—aids distribution throughout the fan.

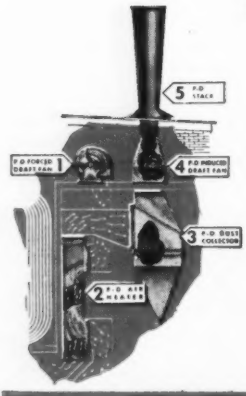


Conventional double wheel with common disc produces concentration, results in poor diffusion.

Performance ratings of the Prat-Daniel F-D Fan are established according to the Standard Test Codes adopted by N.A.F.M. and the A.S.H.V.E.

Design characteristics provide unusually high conversion of Velocity Pressure to Static Pressure. This is accomplished by streamlined inlet cones that are larger in proportion to the wheel than are usually found in forced draft fans. The unusual depth of the cones provide a wider housing than would customarily be used, increasing the space available for diffusion. Precisely fashioned backward curved blades provide a nearly perfect aerodynamic flow across both leading and trailing edges. Double wheel fans are spaced apart to permit four way diffusion of air, further contributing to this conversion. Peak efficiency and horsepower curves fall well within normal fan selection range, offering the optimum in maximum efficiency and non-overloading characteristics.

These are all carefully researched features that have made the Prat-Daniel F-D Fan a highly efficient apparatus. Check these features before you decide on your next fan. Write for catalog No. 300 today.



UNIT RESPONSIBILITY

The Thermix Corp., project engineers for the Prat-Daniel Corp., offer all components required for the handling of air and gas: (1) P-D Forced Draft Fans; (2) P-D Air Pre-Heaters; (3) P-D Tubular Dust Collectors; (4) P-D Induced Draft Fans; and (5) P-D Fan Stacks. This unit responsibility, by a well known firm, relieves the engineer of the necessity of integrating equipment from various sources into the over-all project.

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power plants. Operating experience in central stations using Bunker C oil is very limited, but it is indicated that when operating on this type of fuel, gas turbine maintenance will not exceed that for other types of generating units.

Comparisons of Various Types of Gas Turbines

Before making comparisons between gas-turbine generating units and other types of generation, the field of application of each of the three types of gas turbines described above will be considered. It can be assumed that maintenance and operating labor cost for each type of unit will be the same and so the choice of the type will depend on the installed cost per kilowatt, the cost of fuel, the expected load factor and possibly on the availability of cooling water.

Assuming fixed charges at 12 per cent per year on the installed cost and a load factor of 100 per cent, if the cost of fuel is above about 11 cents per million Btu it will be more economical to use the high efficiency compound cycle unit. If the cost of fuel is below this point, the choice would be between the regenerative and the simple cycle units. If the gas turbine units are intended for peaking plants, the dividing point on fuel cost will be much higher and it may be economical to use a simple-cycle unit even where fuel costs are high.

Gas Turbine vs. Diesel Stations

In making general comparisons between gas turbine and diesel electric generating stations there are several characteristics of the two types of units that must be considered:

1. The overall heat rate of most diesel engines is somewhat better than that of the compound-cycle gas turbine. An average figure for diesel engines is approximately 11,000 to 11,500 Btu per kwhr, as compared to slightly less than 13,000 Btu per kwhr for the gas turbine.

2. Many operators of diesel generating stations operate their diesel engines below nameplate rating at all times in order to minimize maintenance expenses. The amount of derating varies widely but in some cases is down to 80 per cent of nameplate rating. As contrasted with this, the compound-cycle gas turbine can deliver its full nameplate rating at all ambient air temperatures up to 110 F and can deliver up to 25 per cent in excess of nameplate rating at low air temperatures. This extra capability is not firm capacity but is an extra dividend that can be realized in most parts of the country during a large part of the year. Whether full advantage can be taken of this extra capability depends upon the nature of the power system load and whether the system peak occurs during the winter or the summer.

3. The installed cost of a diesel generating plant may be slightly less than that of a compound-cycle gas turbine plant if based on the nameplate ratings of the machines. If based on the actual operating capabilities of the two units, the installed cost of the gas turbine station should be less.

4. The cooling-water requirement of a

diesel generating station is about 25 to 50 per cent more than that of a compound-cycle gas turbine station.

5. Gas turbines have a negligible lubricating oil expense whereas diesel engine lubricating oil cost may be as much as 0.35 mils per kwhr.

6. Gas turbines can operate successfully on either natural gas or Bunker C oil. Dual fuel engines can operate on natural gas as their primary fuel but require that about 5 per cent of relatively expensive oil be burned with the natural gas. This results in an average fuel cost above that of the gas-burning gas turbine and may compensate for the difference in efficiency between the units. In the past, diesel engines have usually been operated on diesel oil which is considerably more expensive than Bunker C oil. Recently however, large, low-speed diesel engines have been developed to operate on Bunker C oil but these engines apparently have somewhat higher maintenance costs.

7. Due to the simplicity of the gas turbine it is expected that maintenance costs will be lower than for reciprocating-type engines.

Taking the foregoing factors into consideration, for most parts of the country, the compound-cycle gas turbine has a slight advantage over the diesel engine on the basis of total yearly costs, including fixed charges. As explained previously, in cases where fuel is very cheap or in peaking plants, the simple-cycle gas turbine would be more economical than the compound-cycle unit and in such applications would show a substantial saving over the diesel generating station.

Gas Turbine vs. Steam-Electric Stations

The compound-cycle gas turbine generating station is lower in installed cost and higher in efficiency than a comparable size steam-electric generating station. Thus it will be more economical if the same fuel is used in both types of generating stations. In areas where coal is considerably cheaper than either Bunker C oil or natural gas, the steam station will obviously have an advantage over the gas turbine.

As steam station size increases, the savings resulting from the use of larger units and the gain in efficiency from using higher steam temperatures and pressures make the steam-electric generating station more economical than a multiple-unit gas-turbine generating station.

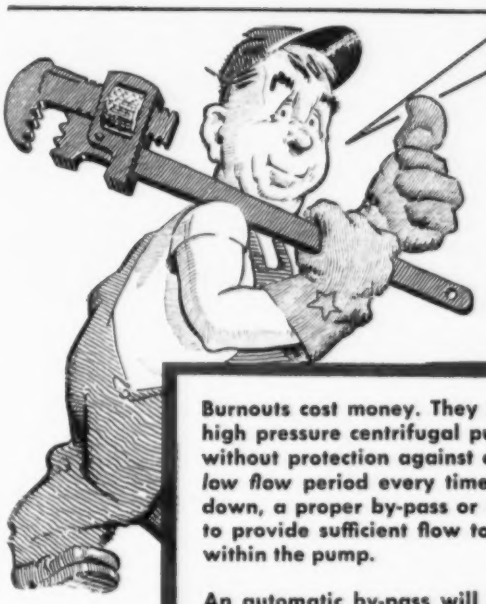
Conclusions

Consideration of the position of the gas turbine relative to other types of power generation, as outlined briefly here, leads to the following general conclusions as to the most probable applications of gas turbines for power generation.

1. As base load units on small and medium sized power systems where relatively small increments of generating capacity can profitably be added.

2. As peaking plants on small and medium sized power systems. In such cases efficiency is often of secondary importance and the less expensive simple-cycle gas-turbine generating unit may be the cheapest type of peaking capacity that can be added. The ease with which the

KEEP MAINTENANCE COSTS DOWN ON BOILER FEED PUMPS WITH FOSTER RECIRCULATING VALVES



Burnouts cost money. They can happen when high capacity, high pressure centrifugal pumps are operated at *low output* without protection against overheating. And since there is a *low flow* period every time the pump is started up or shut down, a proper by-pass or recirculating circuit is essential — to provide sufficient flow to carry away the heat generated within the pump.

An automatic by-pass will do more than just prevent burnouts. It will further cut maintenance costs by reducing impeller erosion due to cavitation and excessive entrained air. It will also prevent power waste by automatically cutting out when the flow is high enough.

The Foster Recirculating Valve is power operated, spring loaded, normally open. Air supply to the power head is through a three-way solenoid valve controlled by a switch operated by the pressure drop across a metering element in the discharge line. When the discharge flow is below a satisfactory minimum, the valve stays open, permitting recirculation. It guaranties that the pump will never run dry (have zero flow while running). When, however, the discharge flow is satisfactory, the valve closes, preventing power waste.

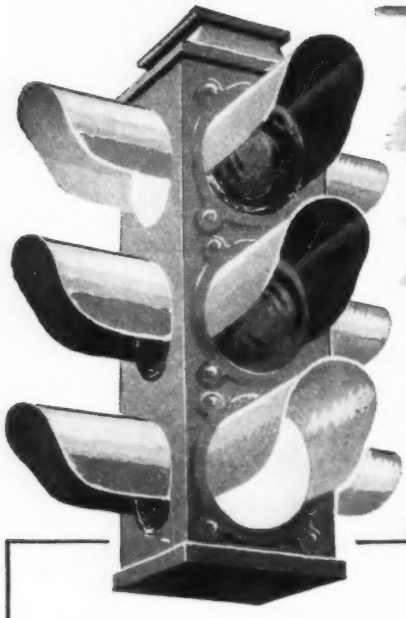
The Foster Recirculating Valve can be used in conjunction with any suitable controlling device.

Typical Foster Recirculating Valve installation in a large Eastern Utility. Since the first six were installed in 1937, eighteen more have been installed as standard equipment to protect boiler feed pumps.

FOSTER ENGINEERING Company

835 Lehigh Avenue • Union, N. J.

PRESSURE REGULATORS . . . RELIEF AND BACK PRESSURE VALVES . . . CUSHION CHECK VALVES . . . ALTITUDE VALVES . . . FAN ENGINE REGULATORS . . . PUMP GOVERNORS . . . TEMPERATURE REGULATORS . . . FLOAT AND LEVER BALANCED VALVES . . . NON-RETURN VALVES . . . VACUUM REGULATORS OR BREAKERS . . . STRAINERS . . . SIRENS . . . SAFETY VALVES . . . FLOW TUBES



DRAFT FANS

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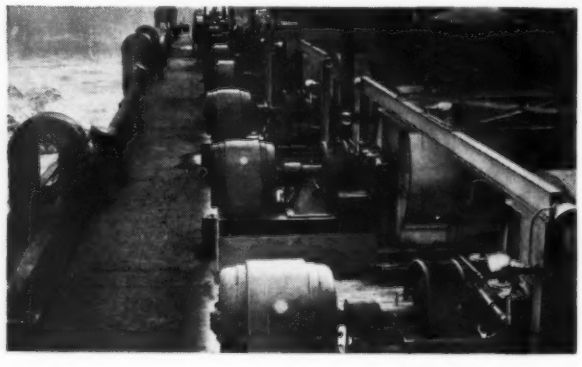
A Big Draft Job Handled Capably by Green Fans

Twenty-four large Green Fans take care of a heavy draft load at the Venice (Illinois) Plant of the Union Electric Co. of Missouri. Each of six boilers has two sets of Green Fans, each set consisting of one induced draft fan and one forced draft fan coupled to one motor as a unit. With the heavy demands on this station, all boilers are usually in service continuously, thus throwing an unrelenting burden on the fans.

Engineers whose responsibility it is to recommend or accept draft fans for large power plants certainly want efficiency and low operating costs. But they don't overlook the maintenance and replacement angles. They want the sound designs of competent experienced fan engineers. They also want the care in construction that is found in shops of a company that has built up an international reputation as the "authority" on draft fans. They know that such a company will not tolerate sloppy shop work.

Green is this authority on mechanical draft fans.



Have You a Copy of Our Fan Bulletin No. 168? If not, we shall be glad to send you one.

THE GREEN Fuel Economizer COMPANY INC.

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gas turbine can be started and stopped makes it particularly suitable for this application.

3. As end-of-line generating plants on some systems. This application is contrary to the trend of power generation over many years which has resulted in systems with a few large generating stations near the main load centers and transmission of power to outlying areas. While the advent of the gas turbine does not radically change this general picture, the simplicity of a gas-turbine generating station, its comparatively low first cost, and the possibility of building unattended remotely operated stations, may make end-of-line plants economically feasible.

4. In some special cases where the relatively large amount of heat available in the exhaust gases from a simple cycle gas turbine can be used to advantage in the heat cycle of an adjacent steam-electric generating station. This exhaust heat can be used either for feedwater heating or for production of low-pressure steam.

5. The simple-cycle gas turbine can be mounted, together with all necessary control, switchgear, step-up transformer and auxiliary starting equipment on either one or two railway cars. Such mobile generating units can provide a utility a means of rapidly restoring service in an area devastated by a storm or other causes, or for service during planned outage of a section of a system for maintenance.

The gas turbine as a prime mover for power generation is very new and so it can reasonably be expected that within the next few years there will be many new developments.

New President of Stevens Institute of Technology

Dr. Jess H. Davis, president of Clarkson College of Technology, Potsdam, N. Y., has been elected to succeed Dr. Harvey N. Davis who is retiring as president of Stevens Institute of Technology, Hoboken, N. J. The new president is the fourth in the 81-year history of the college and will assume his duties in September. He is a graduate of Ohio State University and has had a varied and distinguished career as an engineering educator and industrial consultant. His industrial career has included service with Ohio Bell Telephone Co., Alabama Power Co., American Locomotive Co. and Foster Wheeler Corp., and as consultant for several other firms.

The career of Doctor Davis as an educator started in 1929 when he went to Clarkson College as an instructor in mechanical engineering. By 1940 he had become a full professor; in 1946, dean of administration; and president in 1948. During a two-year interval, he served as professor and head of the department of mechanical engineering at the University of Louisville's Speed Scientific School.

The new president of Stevens is a licensed engineer in New York and Kentucky. His professional societies include the American Society of Mechanical Engineers, the Engineering College Administrative Council, the American Society for Engineering Education, and the Kentucky Society of Professional Engineers.

AIEE Plans Meetings at Portland and Cleveland

Two general meetings of the American Institute of Electrical Engineers, are scheduled for late summer and fall. The first is the Pacific General Meeting which will be held at Portland, Ore., Aug. 20–23, and the second is the Fall General Meeting at Cleveland, Oct. 22–26. These meetings are in the wake of the Summer General Meeting of the Institute which will be held at the Royal York Hotel, Toronto, Canada, June 25–29.

The Pacific General Meeting will be held in the Multnomah Hotel, Portland, and will offer "a well-rounded program with very pertinent technical sessions and inspection trips" to interesting industrial and civic points in and about Portland, including the Bonneville Dam Power House, 40 miles east of the city on the Columbia River.

Ward S. Patterson

Ward S. Patterson, executive assistant to the vice president in charge of engineering, Combustion Engineering-Superheater, Inc., New York, died at the Northern Westchester Hospital, Mt. Kisco N. Y., on May 21.

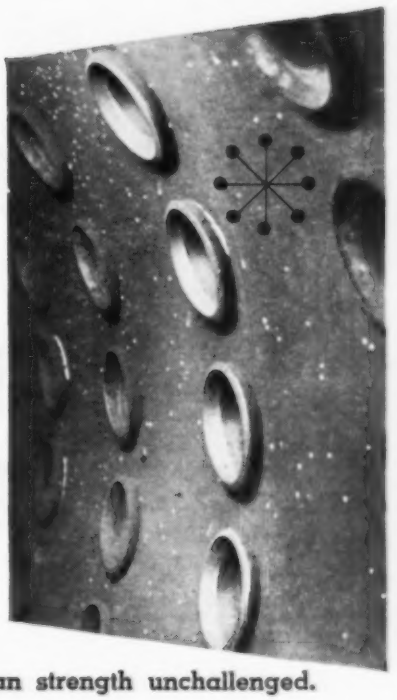
Born in Rangeley, Me., November 3, 1904, Mr. Patterson studied engineering at Cornell University, graduating in 1926

with the M.E. degree. He was a member of Tau Beta Pi—an honorary engineering fraternity.

Joining Combustion Engineering immediately upon graduation, he served in various capacities, later heading up the calculating engineering group and more recently becoming executive assistant to the vice president in charge of engineering. Here he was charged with research and development responsibilities, particularly in connection with controlled circulation for boilers, in which he was a specialist.

Widely known in engineering circles, both here and abroad, Mr. Patterson had been an active member of the American

STRENGTH that FORESTALLS ATTACK



Adequate defense may well mean strength unchallenged.

In boiler operation, scientific feedwater control defies corrosion's threat of aggression. Yet a factor-of-safety allowance in boiler design admits the possibility of sneak-attack penetration of even this powerful defense. Only *total preparedness* — utilization of *every* recognized means of preventing such attack — can assure security in any degree.

You get such total preparedness when APEXIOR NUMBER 1 brush-applied surfacing builds into boiler drums and tubes a margin for error that permits steel to take in stride any deviation from straight-line performance. APEXIOR becomes your first line of defense, holding losses to an expendable maintenance item — never exposing steel to risks that are always costly even though calculated.

Where ideal conditions make few police-action demands on a protective coating, APEXIOR's positive contributions to boiler performance are yours for an extended service life. Smooth APEXIORized metal repels deposits to keep heat transfer high and distribution uniform . . . to improve evaporation and circulation . . . to assure less costly cleaning, mechanical or chemical, for APEXIOR is inert to all acid-cleaning solutions.

8-page Bulletin 1530 tells you more about boiler APEXIORizing. Let us send you a copy.

Unretouched photograph showing APEXIORized boiler steel as it came out of service after 14 months operation at 1250 pounds pressure

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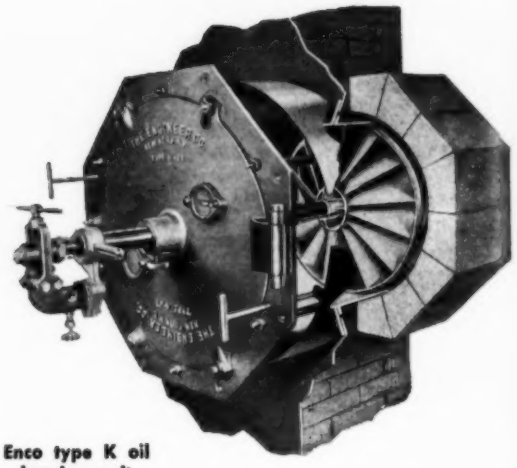
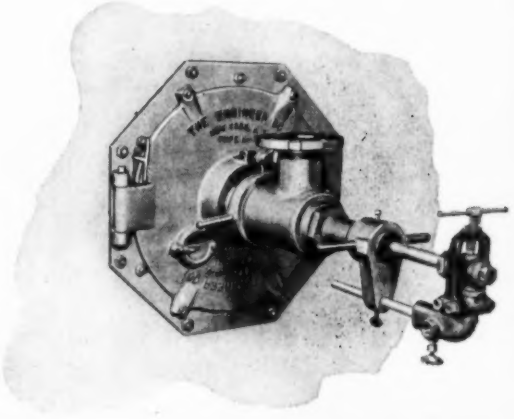


Enco type K oil burning unit

High load or low, you can count on completely uniform combustion and greater fuel economy with the Enco Type K Oil and Gas Burner Unit. It is flexible three ways . . . (1) designed for use with either oil or gas—or both, (2) flexible where steam demands swing sharply and (3) can be operated by either natural or forced draft.

ENCO BURNER UNITS ARE MADE in many sizes to suit all capacity requirements.



Enco type K gas-oil burning unit

Enco Interchangeable Atomizers

Wide Range Mechanical—Capacity range of 10 to 1. Manual or automatic control. Constant high oil pressure at atomizer insures efficient atomization over entire load range without recirculating or returning oil.

Steam or Air—Capacity range of 10 to 1. Controlled by manual or automatic pressure regulation.

Standard Range Mechanical—Available in all sizes to suit load and capacity requirements.

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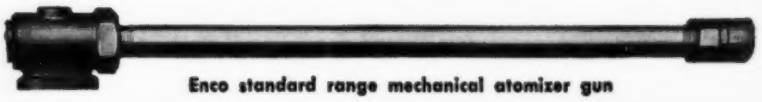
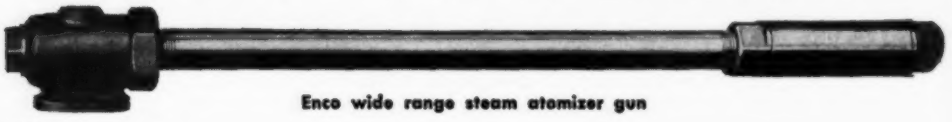
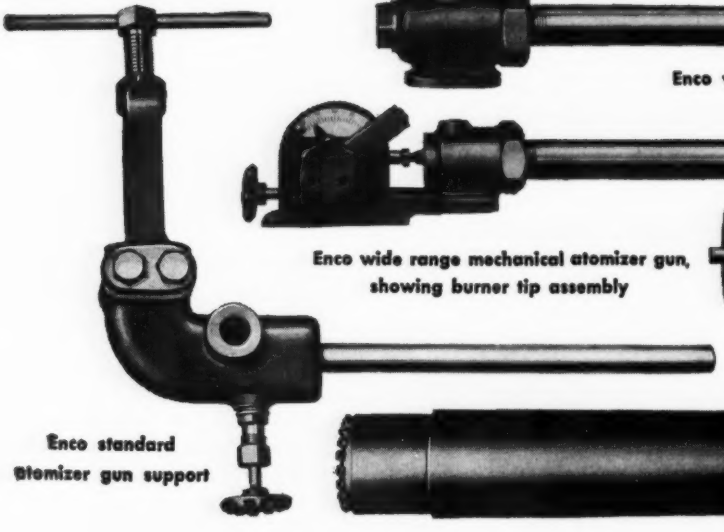


Enco standard range mechanical atomizer gun



Enco wide range steam atomizer gun

Enco wide range mechanical atomizer gun, showing burner tip assembly



Enco standard atomizer gun support

Enco gas burning gun

EC-482

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Society of Mechanical Engineers for the past 25 years, taking part in much committee work and as the author of numerous technical papers. Last summer he delivered an outstanding paper before the World Power Conference in London. Also, he held many patents in the field of boiler design.

A resident of Chappaqua, N. Y., immediate survivors are his wife and two children.

James H. Kenny

James H. Kenny, a contract engineer for Combustion Engineering—Superheater, Inc., died on May 12 at the age of 48. A native of New York City and a graduate of St. Francis College and Brooklyn Polytechnic Institute, Mr. Kenny joined the Drafting Department of Combustion in 1936 and transferred to the Engineering Department in 1941. Most of his work was in connection with the design and application of VU steam generating units. He is survived by a daughter and two sons.

Personals

Arno C. Fieldner, chief of the Bureau of Mines' Fuels and Explosives Division, has been named chief fuels technologist on the staff of Director Boyd; and **Louis C. McCabe,** formerly assistant to Dr. Fieldner and also chief of air and stream pollution prevention research, has been promoted to chief of the Fuels and Explosives Division.

Proctor G. Kuhnen has joined the staff of Gibbs & Hill, New York firm of consulting, designing and construction engineers, as construction manager; also **T. R. Oberg** has been appointed personnel director.

Wilson P. Green, assistant chairman of applied mechanics research at Illinois Institute of Technology, has been promoted to chairman of a new heat-power research department.

Neil J. Braski, superintendent of the power department of the Diamond Alkali Co., at Painesville, Ohio, has been made plant engineer and is succeeded by Jack R. Horacek.

Atmospheric Sampling to Be Studied

A new technical committee, D-22, has been organized by the American Society for Testing Materials to concentrate on the formulation of methods for atmospheric sampling and analysis, as well as stimulate research. Dr. L. C. McCabe, chief of the Air and Stream Pollution of the U. S. Bureau of Mines, has been designated temporary chairman of the committee. It will not be concerned with the fixing of permissible limits or with enforcement problems.

Among the subjects which the committee is expected to consider are the need for both integrated and instantaneous sampling procedures.

Business Notes

The Hays Corp., Michigan City, Ind., announces several recent appointments within its organization. These include: Jack J. Tipton to the position of chief project engineer; Orval M. Riggs, manager of application engineering; and John R. Heming, project engineer for combustion control.

The Dampney Co. of America, Boston, Mass., has promoted Lachlan W. MacLean to the newly created position of vice president in charge of manufacturing and engineering. He has been with the Company since 1936.

Warren Steam Pump Co., Warren, Mass., to meet demands of industrial expansion in the Baltimore area, has appointed Harry W. Faunt Le Roy & Associates, Standard Oil Bldg., Baltimore, as its agent.

De Laval Steam Turbine Co., Trenton, N. J., has named T. A. Nilsen as manager of a new Texas district office recently opened in the Esperson Bldg. at Houston. A. N. Sarich will continue as southwest technical representative for Oklahoma and Texas with headquarters in the new Houston office.

L. J. Wing Mfg. Co., Linden, N. J., manufacturer of heating, ventilating and combustion equipment, has appointed Frank Story publicity manager with advertising and sales promotion responsibilities.

The Swartwout Co., Cleveland, has appointed A. P. Jeffery power plant equipment sales engineer for the Albany and Schenectady territories.

General Electric Co. announces the appointment of Lawrence R. Lee as assistant to the manager of engineering for its turbine division; Alan Howard, operation manager for its gas-turbine division; and J. P. Keller, assistant operation manager for that division.

Infilco Incorporated has completed removal of its executive and engineering offices to Tucson, Ariz., with the establishment of its advertising department at that location under Norman H. Tripplehorn. The factories and laboratories remain in Chicago.

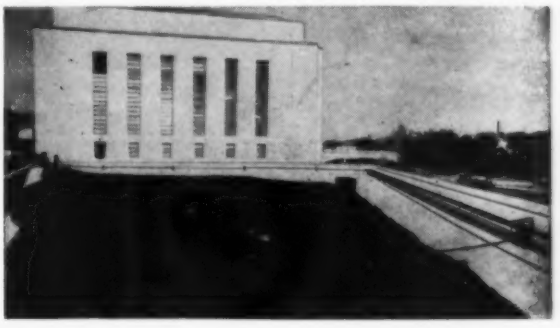
Link Belt Co., Chicago, has appointed Robert W. Suman chief engineer of its Philadelphia plant, replacing W. S. Campbell who has retired.

Graver Water Conditioning Co. has named Flagg, Brackett & Durgin, Inc., as its New England representative, located at 405 Park Square Bldg., Boston 16.

%Proportioneers, Inc.%, Providence, R. I., manufacturers of chemical proportioning and feeding equipment, has acquired Synchro-Master Co., formerly of Seneca Falls, N. Y. It will be operated as a division of the parent company with production facilities located in Providence.

Westinghouse Electric Corp. has appounted Robert C. Twombly manager of its general-purpose turbine application-engineering section of its steam division at Philadelphia.

only a 1 MAN JOB



Storing Coal with a SAUERMAN SCRAPER

Yes, a Sauerman Power Drag Scraper, whether it is a small machine storing and reclaiming a hundred tons a day or a large installation handling thousands of tons a day—can be operated with ease by one man.

This low labor expense is just one of many reasons why Sauerman equipment is chosen to take care of stockpiling at so many power plants. Other advantages of this equipment are its reasonable first cost, almost negligible maintenance expense and the fact that it builds a pile in well-packed layers so that there are no voids to cause spontaneous combustion.

STORY BEHIND THE PICTURE

Above is a Sauerman scraper storing coal at Washington's West Central Heating plant. A 100 hp. Sauerman machine, equipped with a trolley and monorail at the tail end, handles a 16,000-ton stockpile on a small triangular area alongside the plant. Being in a residential section of the nation's capital, it was essential to use a clean handling method, and this was an added reason for choosing the Sauerman scraper. The operator is in a cab overlooking the storage area and all he has to do is manipulate switches controlling the scraper hoist and the monorail winch.

Advice and Literature

Write us about your storage problem. Our catalog and suggestions on equipment will be mailed to you without obligation on your part.

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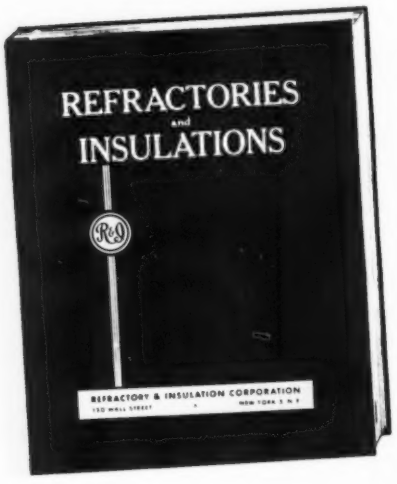

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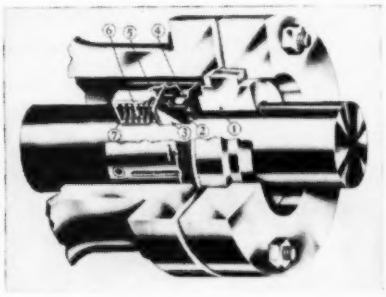
New Equipment

High-Head Pumps

Economy Pumps, Inc., division of Hamilton-Thomas Corp., Hamilton, Ohio, has redesigned its line of Type DMD two-stage pumps. Improvements have been made in compactness, pumping efficiency and mechanical ruggedness. The pumps are made with discharge sizes of 2 to 10 in., capacities up to 4000 gpm and heads to 750 ft. The impellers are of the opposed type and radial load is supported by a double-row ball bearing.

Mechanical Seal

A high-temperature, anti-corrosive mechanical seal incorporating a flexible ring molded from Teflon has been developed by the Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill. Replacing the leather or synthetic rubber member used in most flexible seals, the new plastic ring makes use of the chemically inert properties of Teflon and its high heat resistance. The seal can be employed at temperatures up to 500 F and is designed for application on shafts of centrifugal pumps, turbines,



positive-displacement pumps and agitators. The metal retainer (*7*) provides a positive drive from shaft to carbon-sealing washer (*2*) through dents (*4*) which fit into washer notches. The Teflon wedge ring (*3*) is pre-loaded by the action of multiple springs (*6*), the pressure of which is distributed by a metal disk (*5*). The face of the rotating sealing washer (*2*) mates against the lapped face of the stationary seat (*1*) to provide a leakproof seal with minimum friction between vertical faces.

Refractory Coating

The Power Chemicals Division of E. F. Drew & Co., Inc., 15 E. 26th St., New York 10, N. Y., has developed a new and improved refractory coating that is said to dry to a diamond-hard finish. When dry the coating becomes practically an integral part of the brick and expands and contracts uniformly with the brick. Advantages claimed for the coating are that it provides a smooth hard surface resulting in greater reflection of heat, offers greater protection and longer brick life, and permits boilers to be fired immediately after application. It comes in liquid form and may be brushed on or sprayed.

Regulating Valves

A complete line of flow regulating valves known as Swartwout Type V10 is announced by The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio. Designed to handle steam and water at high-pressure drops, the valves may be used for drainage for stage heaters, evaporator coils, flash tanks, boiler blowdown, feed-pump recirculation and other severe service conditions. All internal parts of the valve are of heat-treated stainless steel ground to precision fit. The valves are available in seven pipe sizes ranging from 1 to 4 in. in 150 to 600-psi standards. Some sizes can be furnished in 900–1500 and 2500-psi standards.

Gage Valve

Edward Valves, Inc., East Chicago, Ind., is offering an additional design of half-inch forged-steel gage valve with a male inlet and female outlet. The male inlet is an integral part of the valve body and has an extra heavy wall thickness to provide greater protection against breaking off. Features include a safety taper-threaded joint between the body and bonnet, a taper semi-needle chromium stainless steel stem disk, and a back-seating shoulder for repacking under pressure. The valve is available in globe and angle designs at ratings of 4000 lb at 150 F or 600 lb at 750 F.

Whiton SOLID STEEL ROTOR STEAM **TURBINES**

WHITON LABYRINTH SHAFT SEAL . . . SINCE 1911

Whiton Turbines in service 25 years without seal replacement

BECAUSE:

- **Factory run-in assures perfect seal and minimum wear.**
- **Labyrinth seals do not contact shaft, eliminating wear and seizing.**
- **Steam ejector feature positively prevents steam leakage at outer end of shaft seal.**

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WHITON MACHINE COMPANY
New London 14, Conn., U.S.A.

New Catalogs and Bulletins

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York, 16, N. Y.

Ash-Handling Systems

Allen-Sherman-Hoff Co. has prepared an attractive 20-page brochure, No. 251, on Hydrojet ash-handling systems. Basic arrangements and advantages are explained for applications to continuous slag-tap furnaces, intermittent slag-tap furnaces, V-type dry-bottom furnaces, stoker furnaces and replacement installations. Operating and construction advantages are explained along with methods of ash disposal.

Block Insulation

A four-page folder on Johns-Manville Superex block insulation tells of the economic advantages and principal properties of this insulation. The information is supplemented by conductivity and heat-loss graphs and a recommended thickness table.

Blowdown Valve

A four-page bulletin prepared by Kaye & MacDonald, Inc., contains details on the K-Master continuous blowdown assembly. A sectional drawing shows features and methods of operation.

Feedwater Control

An exceptionally informative 16-page bulletin entitled "Boiler Feed Water Control at Plants Yates, Atkinson and Arkwright of Georgia Power Company" has been prepared by the Northern Equipment Division of Continental Foundry & Machine Co. This Copes performance report describes the types of feedwater control at each plant and shows typical charts of steam flow, water level and water flow. A brief description of each plant is also included.

Fuel Oil System

Bulletin 109-B prepared by the Peabody Engineering Corp. discusses wide-range oil-burning systems and explains the function of differential pumps for delivering controlled flow to the burners. Photographs of the oil-burner installation at the Redondo Steam Station of Southern California Edison Co. are shown in the four-page folder.

Nozzles and Welding Necks

Catalog 501 prepared by Taylor Forge & Pipe Works describes and illustrates various types of forged steel nozzles, welding necks and large-diameter flanges for boilers, heat exchangers and other pressure vessels. A special 32-page section of the catalog entitled "Modern Flange Design" contains detailed engineering information and methods of calculation of flange stresses and proportions. This attractive catalog has more than 100 pages and numerous tables to enable proper selection of nozzles and flanges.

Pre-Fabricated Piping

Western Piping Supply Division of The Lummus Co. has prepared a two-color eight-page bulletin entitled "Pre-Fabricated Piping." Besides discussing advances made in high and low-pressure piping subassemblies, the booklet describes and pictures pipe bends, coils, headers, manifolds, Vanstone work, process piping and welded assemblies. Mention is made of the facilities of the Division for fabricating carbon-steel, carbon-moly, alloy and stainless-steel piping over a wide range of diameters and wall thicknesses.

Smoke Alarm

Bulletins 107 and 110 describe the GP Model A indicating smoke alarm and recorder and the GP Model M smoke alarm, both manufactured by the General Power Plant Corp. Photographs of the equipment and methods of installation are shown.

Steam Turbines

A six-page bulletin featuring Terry GAF and ZAF multistage turbines has been released by The Terry Steam Turbine Co. The overspeed governor, governor valves, blades, diaphragms and many other design features are discussed and illustrated. Approximate dimensional drawings are included.

Tube-Supported Walls

A twelve-page, two-color catalog on tube-supported walls for industrial boilers has been made available by Bigelow-Liptak Corp. In addition to describing how walls may be suspended directly from boiler tubes, the catalog contains reproductions of engineering drawings showing typical jobs and indicating how the enclosure is fastened to the boiler tubes.

Vertical-Drive Steam Turbines

The Whiton Machine Co. has issued a four-page booklet describing and giving technical data on vertical-drive steam turbines. Built in three sizes and suitable for steam conditions as high as 900 psig, 900 F, the turbines are rated from 5 to 600 hp and find application in refineries, marine cargo, geared circulating and boiler feed pumps.

Water Softener

Cochrane Corp. have issued publication No. 4530 on Cochrane Hydrogen Zeolite (Cation Exchange) Softeners. The 16-page bulletin gives a description of the process and the field of application, showing the advantage of hydrogen zeolite softening and its relation to sodium zeolite softening.

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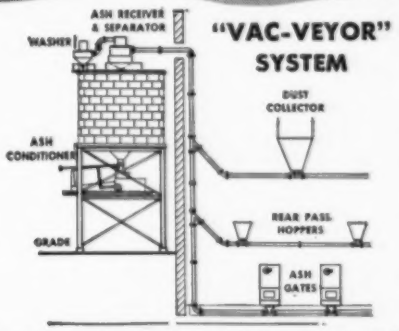

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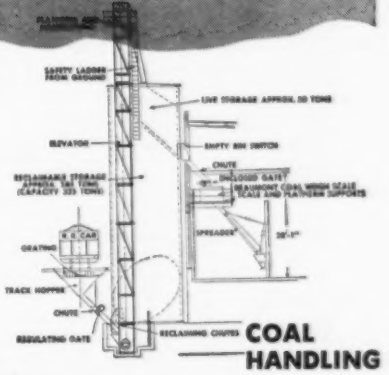

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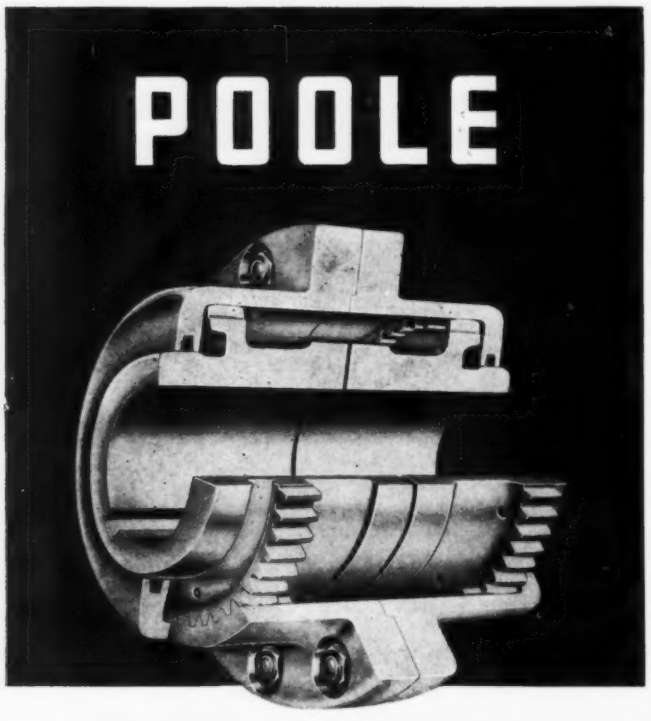

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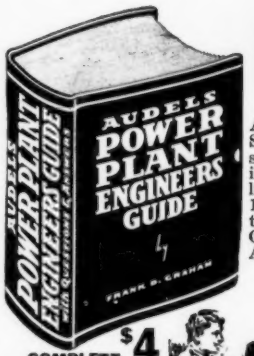

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